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THE SANTEE RECREATION PROJECT SANTEE, CALIFORNIA

Public Health Service
San Francisco, California

June 1963

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THE SANTEE RECREATION PROJECT

SANTEE, CALIFORNIA

ANNUAL PROGRESS REPORT FOR 1962

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U.S. DEPARTMENT OF HEALTH, EDUCATION AND WELFARE
REGION IX
PUBLIC HEALTH SERVICE
BUREAU OF STATE SERVICES
DIVISION OF WATER SUPPLY AND POLLUTION CONTROL
SAN FRANCISCO, CALIFORNIA

113

JUNE 1963

THE SANTEE RECREATION PROJECT

SANTEE, CALIFORNIA

ANNUAL PROGRESS REPORT FOR 1962

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ERRATA SHEET
for

The Santee Recreation Project, Santee, California
Annual Progress Report 1962

U.S. Public Health Service, June 1963

Please make corrections in your copy of the subject report as indicated below:

Cover - Date at bottom: Change from "MAY 1963" to "JUNE 1963"

Page 1 - Senior author's name: Change from "MERREL" to "MERRELL"

Page 3 - Add to list of sampling station locations in the first paragraph: "8. Effluent at Lake 4 Outlet"

Page 4 - Fifth line from bottom: Change from "specie" to "species"

Page 8, 2nd paragraph, line 3: Add "cubic" after "245"

Page 10, line 2: Change from "Lakes" to "lakes"

Page 11, last line: Add "ship" to the word "relation"

Table 1 - Heading "Air Temperature": Add "Degrees F."

Table 3 - Title: Add "– MGD"

Table 4 - Heading of third column: Change from "MGO" to "MGD"

Page 14, Line 10: Capitalize the first letter in the word "November"

Page 14, 4th line from bottom: Change from "is" to "are"

Page 16, line 11: Add "the" after the word "be"

Page 18, line 10: Change from "indluent" to "influent"

Page 18, line 14: Change from "bachwash" to "backwash"

Figure 11 - Caption: Change from "N_2" to "Na"

Page 23, 4th line from bottom: Change from "l.e." to "i.e."

Table 6 - Heading of last column: Change from "Aug." to "Avg."

Table 6 - Column under "AUG.", opposite "POND B.CL. Coliform": Delete the decimal point in front of the figure "80"

Page 26, line 12: Change from "dominanace" to "dominance"

Page 26, line 14: Change from "larva" to "larvae"

Page 26, line 18: Add a comma between "species" and "the"

Page 27 - Rewrite 1st paragraph to read as follows: "It may be concluded from the biological studies during this first year that the system is operating quite satisfactorily, that no serious plant or animal nuisance conditions have arisen and that it is possible to provide a good recreational fishery."

Page 29, line 13: Change first letter of first word to lower case

Page 31, line 1: Change from "*Chroederia*" to "*Schroederia*"

Page 33, line 1: Change from "were" to "was"

Page 35, line 9: Underline "Hetromastix"

Page 37, line 8: Change from "true oxidation" to "stabilization"

Page 37, line 11: Change from "oxidation" to "stabilization"

Page 38, line 3: Change from "Neverthe-less" to "Nevertheless"

Page 38, line 16: Change from "ABS" to "detergent"

Page 39, sentence beginning on the 7th line from the bottom of the page: Change to read "In three cases, the dominant genus exceeded 50 per cent of the total: *Chroomonas* at 62 per cent in the second week of October, *Chlamydomonas* at 78 per cent in the second week of November and *Hetromastix* at 80 per cent in the second week of December."

Page 40, line 8: Change "B-16" and "B-36" to "B-1b" and "B-3b" respectively

Page 41, line 1: Change "Lake 1" to "the Oxidation Pond"

Page 42, line 15: Change from "68" to "368"

Page 46, line 9: Change from "not" to "now"

Page 48, last line: Add an apostrophe after the word "anglers"

Table 17 - Subtitle: Change from "Medium" to Median"

Table 17, 1st column, under line heading "Coliform": Change from "MDN" to "MPN"

Table 17 - Inlet column, opposite "BOD": Change from "34" to "3.4"

Table 17 - Outlet column, opposite "ABS": Change from "32" to "3.2"

Page 53, line 11: Change from "Lake" to "lake"

JCM-HEP/8-13-63/ (250)

V.

THE SANTEE RECREATION PROJECT

SANTEE, CALIFORNIA

ANNUAL PROGRESS REPORT FOR 1962 *

by

JOHN C. MERREL, JR. AND HERBERT E. PINTLER **

Introduction

The Santee Recreation Project was designed to determine in the field the optimum procedures necessary to manage water quality through a waste treatment and water reclamation system supplying water for recreational lakes, recharge and irrigation. The primary impetus for the research project resulted from the need of the County and State Health authorities for information regarding the presence of viruses in reclaimed waters when the Santee County Water District decided to use its well treated effluent water for recreational lakes. The extent of the research incorporated in the final project was broadened to include not only virus identification but also related chemical, physical and bacteriological pollution indicators. Separate studies of hydrology, vector control, fish propagation and aquatic biology were also set up to make more effective use of correlating data obtained originally for the virus study.

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* Processed and distributed by the Division of Water Supply and Pollution Control, Public Health Service, Region IX, U. S. Department of Health, Education, and Welfare, Rm. 447 Federal Office Building, San Francisco 2, California.

** Respectively, Sanitary Engineer/Project Coordinator, The Santee Recreation Project, and Regional Biologist, Division of Water Supply and Pollution Control, Public Health Service, Region IX, U. S. Department of Health, Education, and Welfare, San Francisco, California.

The research has been conducted with the assistance of representatives of the various cooperating agencies as follows: (1) San Diego County Department of Public Health: J. B. Askew, M.D., Roderick F. Bott, Beatrice England, Raymond E. Leach; (2) Santee County Water District: Martin Poe, Ray L. Stoyer; (3) California State Department of Public Health: Kirkham W. Campbell, Arnold E. Greenberg, Harvey I. Magy, Remo Navone, Arthur Reinhardt, William E. Reynolds, M.D., Edward A. Reinke, Frank M. Stead, Paul C. Ward; (4) California State Department of Water Resources: Arthur J. Inerfield, David B. Willets; (5) California State Department of Fish and Game: John A. Calaprice, Jack C. Fraser, Marvin J. Whalls; (6) California State Water Pollution Control Board: Paul Beerman, Paul R. Bonderson; (7) San Diego Regional Water Pollution Control Board: Leonard Burtman, Dennis A. O'Leary; (8) U.S. Public Health Service: Paul W. Eastman, Albert Katko and various members of the Division of Water Supply and Pollution Control, Washington, D. C. and the Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio. Many others have provided assistance or consultation along the way, and their interest and help is also gratefully acknowledged. The memorandum of understanding among six of the above agencies is attached as Appendix A.

Study Program

In February 1962, the first of a series of quarterly studies was initiated by the cooperating agencies to obtain background data for the proposed virus study. The virus study, started in July 1962, is directed by the San Diego County Department of Public Health with personnel and supplies financed by the State Water Pollution Control Board, and equipment and technical assistance provided by the United States Public Health Service. These background studies included analyses for the bacterial indicators: coliform, fecal coliform and fecal streptococci; the sewage treatment parameters: biochemical oxygen demand (BOD), chemical oxygen demand (COD), suspended solids, volatile solids; and chemical and physical quality analyses of all waters in the study area.

Sampling locations include the following as shown in Figure 1.

1. Raw Sewage at Plant Inlet
2. Primary Settled Effluent (In overflow channel)
3. Activated Sludge Effluent (In overflow channel)
4. Oxidation Pond Effluent (Surface of pond at pump)
5. Oxidation Pond Effluent Chlorinated (35 minute contact)
6. Ground Water (Well B) Above spreading basin

X. In the stream carrying percolated water about 200 feet south of spreading basins.

Y. In a ground water collection ditch 2,500 feet south of spreading basins.

7. Collection Gallery at Lake 4 Inlet

Four two-week periods of sampling were conducted at the above stations, one each in February, May, August and November. Sampling frequency varied from four-hour intervals for bacteria to once or twice per week samples for chemical analyses.

Most samples obtained in the recreation project have been grab samples from the flow at the various stations. In a few cases, primarily with mineral analyses, composite samples made up of six separate grab samples obtained at four-hour intervals have been prepared. Each of the grab samples were then proportioned in accord with flow at the sewage inflow meter. These composite samples were used for Stations 1, 2, and 3 for all mineral analyses. During August and November composite samples at these stations were also used for COD, BOD, nitrogen, phosphate and synthetic detergent analyses. Samples from Stations 4 through 8 followed detention times of 30 or more days so that good average characteristics for all chemical constituents were obtained. Samples for Station 4 were obtained by a surface grab procedure in the vicinity of the pump. Samples for Station 5 differed in characteristics since the water was mixed through the pump and piping system following chlorination. The pump inlet setting was at three feet below the surface. Continuous conductivity readings were obtained at two locations to demonstrate the variation in over-all water quality.

An additional set of weekly bacterial analyses has also been made at the San Diego County Department of Public Health Laboratory since March 1962. These samples were collected at 11 a.m. each Monday to correlate with the virus testing program that started in July.

During each of the two-week sampling periods dissolved oxygen and plankton measurements were made. Plankton results included twice weekly counts for the oxidation pond (Lake 1) and Lake 4 (recreation lake) outlet waters and were expanded to include a regular study of Lake 4 in October. Dissolved oxygen measurements have been made on all lakes. A regular vector control study, involving once or twice per month sampling for benthic organisms in all water ways of the project, was started in July to obtain background information regarding numbers and species.

The two recreational lakes (Lakes 3 and 4) have been planted with several species of fish, and continuing studies regarding growth and development of each specie have been carried out by a sampling program of the State Department of Fish and Game. The "Fish for Fun" program operated as a part of the recreation program also provides information regarding growth. No consumption of fish has been allowed.

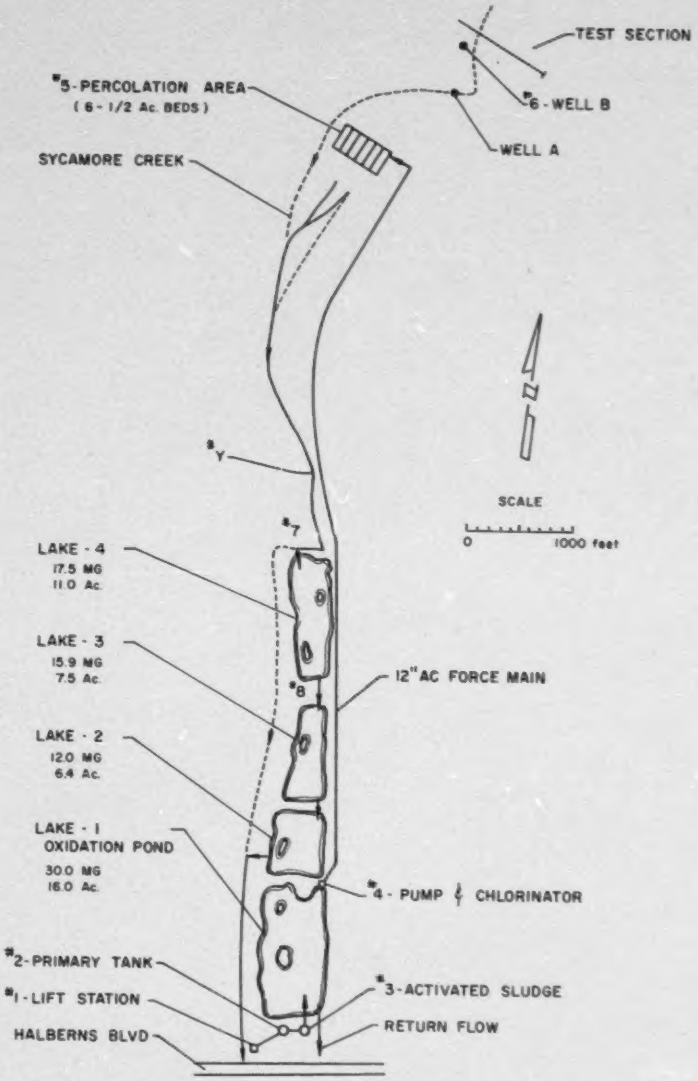
TEST SECTION
#5-PERCOLATION AREA
(6 - 1/2 Ac. BEDS)
#6-WELL B
WELL A
SYCAMORE CREEK
#Y
SCALE
0
1000 feet
#7
LAKE - 4
17.5 MG
11.0 Ac.
LAKE - 3
15.9 MG
7.5 Ac.
#8
12" AC FORCE MAIN
LAKE - 2
12.0 MG
6.4 Ac.
LAKE - 1
OXIDATION POND
30.0 MG
16.0 Ac.
#4 - PUMP & CHLORINATOR
#2-PRIMARY TANK
#1-LIFT STATION
#3-ACTIVATED SLUDGE
RETURN FLOW
HALBERNS BLVD

FIGURE 1

LOCATION MAP SANTEE RECREATION PROJECT

Since the Santee plant operated with no flow measuring equipment other than the readings of the raw sewage pumps, flow data was obtained by rating these pumps at the inlet of the plant and at the outlet of the Oxidation Pond. Rectangular weirs were utilized to measure recirculated flow and flow entering and leaving Lake 4. A hydrological study of the ground water basin above the percolation area was made by the State Department of Water Resources. Methods of analysis generally followed standard methods.

Project Description

The unincorporated community of Santee lies along both sides of the San Diego River channel for a distance of six miles, beginning approximately 15 miles above the river mouth. It is located just north of the City of El Cajon and about 20 miles by road from downtown San Diego. The community is largely residential with only such commercial establishments as are essential to provide for community needs and services. It covers the junctures of both El Cajon Valley and Sycamore Canyon with the San Diego River Valley. There has been no waste producing industry in the community.

Sycamore Canyon, a tributary of the San Diego River, contains only intermittent surface flow. There is subsurface flow, however, both in the San Diego River and in Sycamore Canyon. The canyon extends generally northward from the San Diego River channel to a point slightly over two miles from its junction with the river channel, where a westerly branch extends into the U. S. Government lands and an easterly branch extends into private lands. The easterly branch is available for future use by the District for development as an additional recreational area.

The floor of the canyon is approximately 2000 feet in width at its mouth. It narrows to approximately 1000 feet in width above the recreation lakes. The slope of the canyon is about one per cent with an elevation of 325 feet at the plant. The canyon is underlain with non-water-bearing sediments which have been incised and backfilled with sand and gravel to depths of up to 15 feet. This serves to confine the underground stream which percolates through the sand and gravel.

The area immediately up-canyon from the location of the sewage treatment plant has been extensively worked by a gravel processing industry to a depth of from eight to ten feet. The remaining borrow pits have been reworked into level areas with earthen berms to provide oxidation ponds or lakes to receive the sewage treatment plant effluent. Areas farther up-canyon will continue to be worked as time goes by, and this will result in the creation of additional lakes. Fig. 1 shows the location of the present lakes and treatment facilities.

The area immediately to the east of the canyon is occupied by a development which contains about 1700 residences and extends northward approximately one mile from the mouth of the canyon at the present time. The area immediately to the west of the treatment plant site has also been subdivided and is occupied by about 200 residences at present.

The master plan for development of the canyon provides for a flood channel extending along the entire westerly boundary of the canyon. It also provides for a freeway extending along the easterly edge of the canyon. The treatment plant and the several lakes, which are maintained and operated by the sewering agency, are located between the sites of these proposed facilities.

Treatment Facilities

The Santee County Water District is a public agency which provides water for the 12,000 people living within its district and, in addition, operates a sewering and sewage treatment facility for the entire area. Tributary sewage flow currently equals 0.9 million gallons per day (mgd). The sewage is treated in an activated sludge type sewage treatment plant having a design capacity of two mgd. The entire sewage treatment and water reclamation process consists of the following units:

Unit	Design Capacity
Raw Sewage Lift Station - Comminuter, bar screen 2 pumps, #1--2,200 gpm #2--2,800 gpm	4 mgd
Primary Clarifier 45' i.d. 95,000 gal. vol.	2 mgd
Sludge Digester 45' i.d. 50,000 cu. ft. vol.	2 mgd
Activated Sludge 67' i.d. 380,000 gal. vol. 3 blowers 245 cfm each, 1 mixer & surface aerator with 60 hp	2 mgd
Oxidation Pond 16.0 acres 30 m.g. vol. Elev. 323'	
Transfer Pump 1160 gpm - 60 hp -- 41 psi	
Transfer Line 12" A.C. - 7,700 ft.	
Chlorinator 400# day, Contact Volume = 41,000 gal.	
Spreading Area Elev. 395' 6 basins 100' x 200' area = 3 acres	

Flow measurement equipment is limited to hour meters on the pumps and the operator's log of the chlorinator on the transfer pump from the

Oxidation Pond outflow. Flows into and out of Lake 4 are currently measured by rectangular weirs. The plant is routinely operated with a return flow from the Oxidation Pond of about 200,000 gallons per day (gpd) for odor control. This flow returns to the main trunk sewer ahead of the lift station. Waste activated sludge is also returned to this sewer. Return flow is monitored by measuring the depth over the V-notch or rectangular weir. Supernatant flow from the digester was returned to the primary unit during the February and May sampling periods but was diverted to the oxidation pond during the August and November sampling periods.

The activated sludge unit is a combination aeration and solids contact unit in which the aeration chamber contains about 12 per cent of the total volume of 380,000 gallons. One or two blowers of 245 feet per minute (cfm) each and a mechanical mixer keep this unit in operation. Suspended solids in the mixed liquor have been kept at about 6000 parts per million (ppm) to control foaming. Flow from the activated sludge process enters the 30 million gallon capacity Oxidation Pond at about a ten foot depth near the south end.

Flow from the Oxidation Pond is chlorinated and transferred by a 1200 gallon per minute (gpm) pump to a spreading area 8500 feet north. Chlorination of this flow originally was approximately 925 feet from the outlet pump but was transferred to a point opposite the outlet pump during the May test. Contact time at this pumping rate is about 35 minutes. The spreading area currently consists of six basins of about one-half acre each. These basins are fed by a cross-trench that was originally one of a series of eight trenches in which spreading was carried on. Considerable difficulty has been experienced with the spreading area because of the volume of flow, low permeability and limited hydraulic grade available. The practice has been to pump to the beds for one or two days and then to shut off for as long a period as possible to allow the beds to dry. To assist the sampling program for virus and bacterial analyses, longer pumping periods have been used.

Flow from the percolation area first surfaces about 200 feet below the spreading area. The volume of surface flow developed at this location has continued to increase during the successive test periods. It is estimated that about one-half of the flow is now developed in this stream in the first 1000 feet below the spreading area. Flood flow was diverted around the spreading area, but was mixed with the flow in the stream below. All of the flow developed in the stream is accumulated at a collection gallery which is at an elevation that can recover most of the ground water flow in the valley. A transfer pipe from this collection gallery allows flows up to about three mgd to enter Lake 4. Flows above this quantity enter the flood control channel to the west of the recreational lakes. Flow from the percolation area can also be diverted around the recreational lakes.

Recreational Facilities

The upper two lakes, which have been numbered serially in an up-stream order, are currently used for recreational purposes. The flow pattern is from the percolation area into Lake 4 and then from Lake 4, to Lake 3, to Lake 2 and then back to the flood channel. Both Lake 3 and Lake 4 have diversion weirs that can spill to the flood control channel. Figure 1 illustrates the location of the lakes and their size and volume.

The recreational season at the Santee Lakes is from May through December with the Lakes being open Saturday, Sunday and Holidays from about noon until dark. During school vacation season the lakes are open each day to provide a recreational area for children. Recreational use of the Santee Lakes is limited to boating in sail or rowboats and fishing for fun on limited days only. Use of the grassed areas adjacent to the lakes is primarily for picnicking, but some playground facilities are provided. Special use for scouting or artist activity is occasionally permitted. The valley area outside of the fenced lakes is also used by many children who generally play in the stream waters.

Weather

The weather at Santee is typical of coastal Southern California. Rainfall is less than 15 inches per year. Rains during and preceding the February analyses completely filled the aquifer of Sycamore Canyon until runoff occurred. Surface flows of about four to five cfs were developed and the surface flow was maintained until about the first of April. Most days, during the year, are sunny with typical early morning fog or low clouds that disappear by noon. Winds are generally westerly and blow most vigorously during the afternoon. These winds are capable of causing a riffle on the surface of the higher lakes (Lakes 3 and 4), but generally do not affect the Oxidation Pond. Because they blow across the lakes, they are a beneficial factor in the sailboat activity. Air temperatures at Santee exceed 100 degrees Fahrenheit (F) maximum and can reach freezing during the winter.

Table 1 summarizes precipitation and temperature records for the 1962 year at the nearby airport weather station, Gillespie Field.

Results of the Study Program

A summary of treatment plant flow is presented in Table 2. Average flows for each sampling period have been used to supplement daily pump-hour readings and chlorination log records to provide the year's record. This table shows that raw sewage pumped during the test periods averaged 1.06 mgd, but included 0.15 mgd of recirculated Oxidation Pond effluent. The average net flow entering the plant during the test periods was 0.91 mgd. The summary by month and by quarter for both the raw sewage pumped and the flow pumped from the Oxidation Pond shows that the recirculation rates should average 200,000 gpd to provide a net inflow to the plant of 0.9 mgd. At this rate of flow, the Oxidation Pond losses of approximately 180,000 gpd can be computed. This loss could logically be caused by plant irrigation (30,000 gpd), evaporation (70,000 gpd), and percolation (80,000 gpd). This percolation rate is equivalent to about 0.2 inches per day over the 16-acre Oxidation Pond. Table 3 summarizes the flow to the percolation area and at the inlet and outlet of recreational Lake 4. Also shown on this table are computed ground and estimated surface flows for the canyon above the percolation area. These ground water flows were determined from elevations of test Well B (Station 6), and a bedrock cross section of the valley above the percolation area. At this cross section, test holes were dug to the impermeable bottom formation so that an elevation-discharge relationship could be developed. A summary of this relation is shown in

Table 4. At the normal low water elevations of 394 feet in Well B, a wetted area of about 1425 square feet provides an estimated discharge of 14,000 gpd at a one per cent slope and permeability of 1000 gpd per square foot as suggested in the report of the Department of Water Resources. A hydrograph, Figure 2, shows a partial record of ground water elevations and the flows to the percolation area as well as at the inlet and outlet of the recreational Lake 4. Table 3 indicates that during the year the average flow percolated was 720,000 gpd. An estimated average ground water flow of 40,000 gpd was developed. At this flow the dilution effects of the ground water would be about six per cent.

Percolated flows originally reached the surface in very small volume about 200 feet below the downstream edge of the percolation trenches. After the trenches were replaced with six one-half acre beds in March, increased percolation rates were effected. Following use of the beds, clogging has increased and larger quantities of water now reach the surface stream immediately below the percolation area. During November it was apparent that increased hydraulic gradients of about four per cent slope were causing approximately one-half of the flow to reach the surface stream within 500 feet of the percolation area. Residence time for the full flow under ground at this distance is about one day for sample point "X", and at least 90 days for the smaller flow reaching the surface at sample point "Y". Percolation rates for the 720,000 gpd on three acres equals about 0.75 feet per day, and the saturated zone reaches to the surface of most beds. A reduction in volume of flow percolated is planned for the

TABLE 1

PRECIPITATION AND TEMPERATURE - 1962

AT GILLESPIE FIELD (2 Miles S.E. of Santee)

	Precipitation	Air Temperature	
	Inches	Max.	Min.
JAN	3.45	84	23
FEB	4.07	76	31
MARCH	1.01	78	30
APRIL	T	93	43
MAY	.81	88	45
JUNE	.03	93	49
JULY	0	94	52
AUG	0	98	56
SEPT	0	100	52
OCT	.01	97	44
NOV	.01	90	33
DEC	.36	82	26
TOTAL 1962	9.75	100	23
Range 1951-62		111	19

Avg. 1929-59,13.8

TABLE 2

TREATMENT PLANT FLOW SUMMARY - MGD

	Raw Sewage Pumped				Net Sewage Flow		Pond Eff. Pumped	
	Month-Qtr.-		Test Period	Recir. Flow	Test Period	Quarterly Estimate	Month-Qtr.	
JAN	1.06						.67	
FEB	1.30		(1.17	0.18	.99)		.78	
MAR	1.18						.61	
AVG		1.18				.98		.68
APRIL	1.00						.78	
MAY	1.07		(.99	.07	.92)		.63	
JUNE	1.03						.70	
AVG		1.03				.83		.70
JULY	1.29						.76	
AUG	1.23		(1.07	.15	.92)		.76	
SEPT	.93						.71	
AVG		1.15				.90		.74
OCT	1.05						.87	
NOV	.99		(1.03	.20	.92)		.68	
DEC	1.10						.74	
AVG		1.05				.90		.76
YEARLY AVG.		1.10	1.06	.15	.91	.90		.72

TABLE 3

PERCOLATION AND LAKE NO. 4

	Pumped To	Estimated Natural Flow Sycamore Canyon		Recreation	Lake #4
	Perc. Area	Ground Water	Surface	Inlet	Outlet
Jan	.67	.02	0		
Feb	.78	.04	0.5	1.00	.80
Mar	.61	.10	0.2		
Apr	.78	.06	0.1		
May	.63	.04	0	.95	.75
June	.70	.03	0	.65	.45
July	.76	.02	0	.63	.43
Aug	.76	.02	0	.59	.42
Sept	.71	.02	0	.60	.42
Oct	.87	.01	0	.61	.42
Nov	.68	.01	0	.61	.42
Dec	.74	.01	0	.61	.42
Avg	.72	.04	.07	.6	.4

12d

TABLE 4

ELEVATION-AREA-GROUND WATER FLOW RELATION
in SYCAMORE CANYON

Elevation Well B	Area-Sq. Ft.	Estimated MGO	(For 1% slope and) (K = 1000 gpd/sq. ft.)
392	312	.003	
3	810	.008	
4	1425	.014	
5	2112	.021	
6	2845	.028	
7	3597	.036	
8	4375	.044	
9	5182	.052	
400	6012	.060	
401	6865	.069	
402	7730	.077	

The above table was derived from information furnished by California Department of Water Resources

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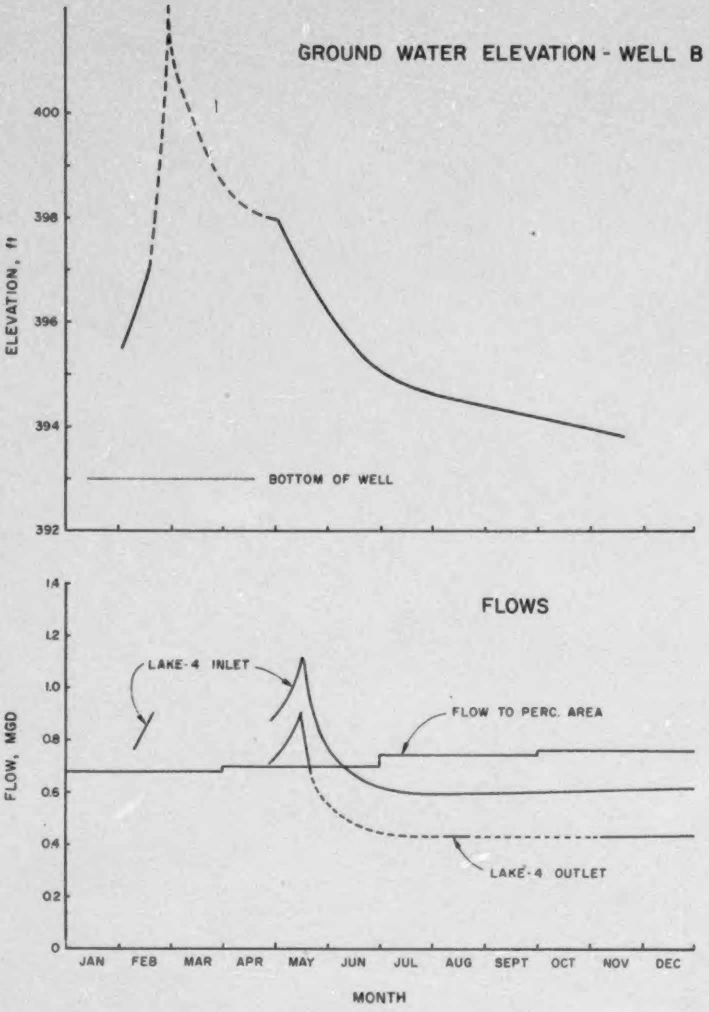

FIGURE 2

HYDROGRAPHY OF THE SANTEE RECREATION PROJECT

SANTEE RECREATION PROJECT
SANTEE, CALIFORNIA

future. Table 3 shows that recovered ground water flow has equaled 600,000 gpd or about 80 per cent of the percolated flow. The losses of flow in the percolation area can be attributed to transpiration or movement around the west dike of Lake 4. Losses from the lake are primarily through the west or south dikes and amount to 200,000 gpd.

Physical and Chemical Quality

The temperature record of the raw sewage for each of the four sampling periods has been summarized to show the range and average for each four hour interval and is depicted in Figure 3. Maximum average variation was from 67 degrees to 84 degrees F. but individual readings ranged from 65 degrees to 84 degrees F. The averages for each of the test periods showed that the daily minimum occurred at 7:00 a.m. with the maximum most often at 11:00 a.m. Figure 4 shows the average temperature readings for four sample points throughout the project for the two-week sampling periods during May, August and November. Maximum temperature ranges occur for the stream entering Lake 4 and the Oxidation Pond surface which was obtained at the narrow cove near the outlet. Maximum temperature ranges of 15 degrees F. are shown for May and 17 degrees F. are shown in August. The maximum water temperature in the Oxidation Pond was 90 degrees F. and occurred in August. Minimum water temperatures in Lake 4 and the Oxidation Pond were 60 degrees F. in November, but dropped to 50 degrees F. later in the year. Daily temperatures for each sample period for the activated sludge effluent and the Oxidation Pond effluent are shown in Figure 5. Some additional temperature records have been combined with dissolved oxygen records obtained for the recreational lakes.

Measurement of dissolved oxygen and temperature were made at several locations on all of the lakes. Maximum variation occurs in the Oxidation Pond where daytime dissolved oxygen concentrations in excess of 20 ppm are usually found at some surface locations. During the August sampling period, both thermal and dissolved oxygen stratification occurred continuously in the Oxidation Pond. No dissolved oxygen was found below the thermocline. During May very little stratification was noted in any of the lakes. In november a relatively great temperature difference was again found but only in the Oxidation Pond. The effect of wind mixing is evidently greater in the recreational lakes than in the Oxidation Pond. It is also obvious from the dissolved oxygen records that the greater oxygen demand of bacterial action in the Oxidation Pond can quickly depress oxygen to minimum levels while the water in each of the other lakes tends to hold dissolved oxygen at levels suitable for fish propagation.

Diurnal variation of dissolved oxygen shows average increases from levels of 13.4 ppm to 21.2 ppm between 7 and 11 a.m. for Lake 4. Dissolved oxygen levels have been shown in Figure 5 for several surface locations for water flowing through Lakes 4, 3, and 2 on four separate days during the year. The variations in biological activity in each of the lakes is apparent.

Suspended and volatile suspended solids measurements were made for all sample stations. Of note are the very high readings for the raw and primary effluents obtained during the February sampling

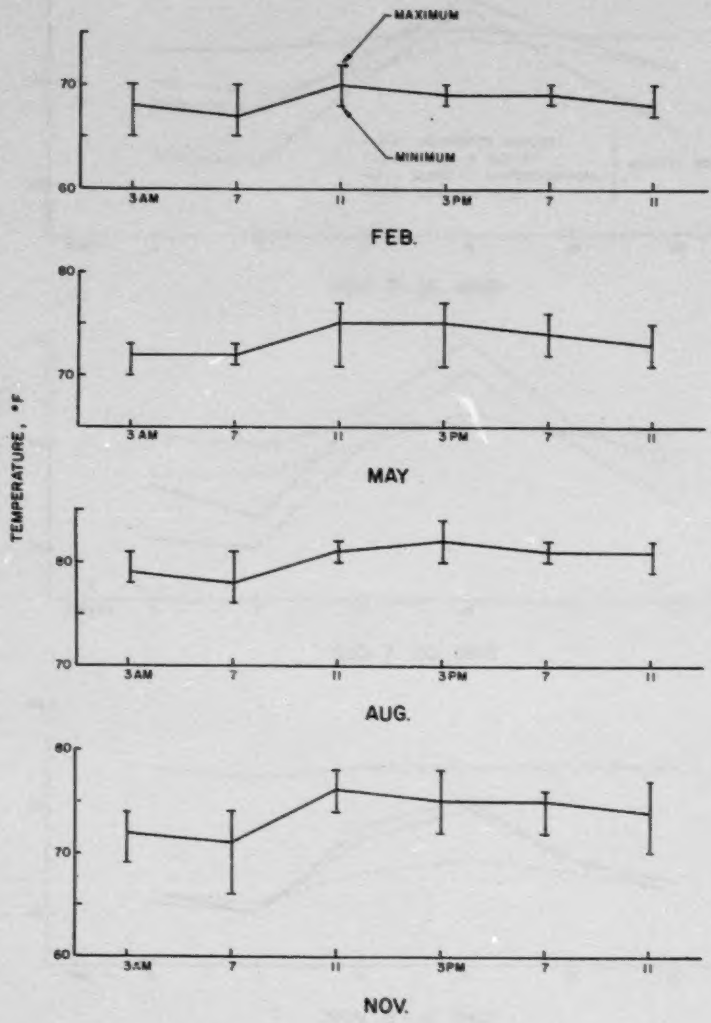

FIGURE 3

RANGE AND AVERAGE RAW SEWAGE TEMPERATURES

SANTEE RECREATION PROJECT
SANTEE, CALIFORNIA

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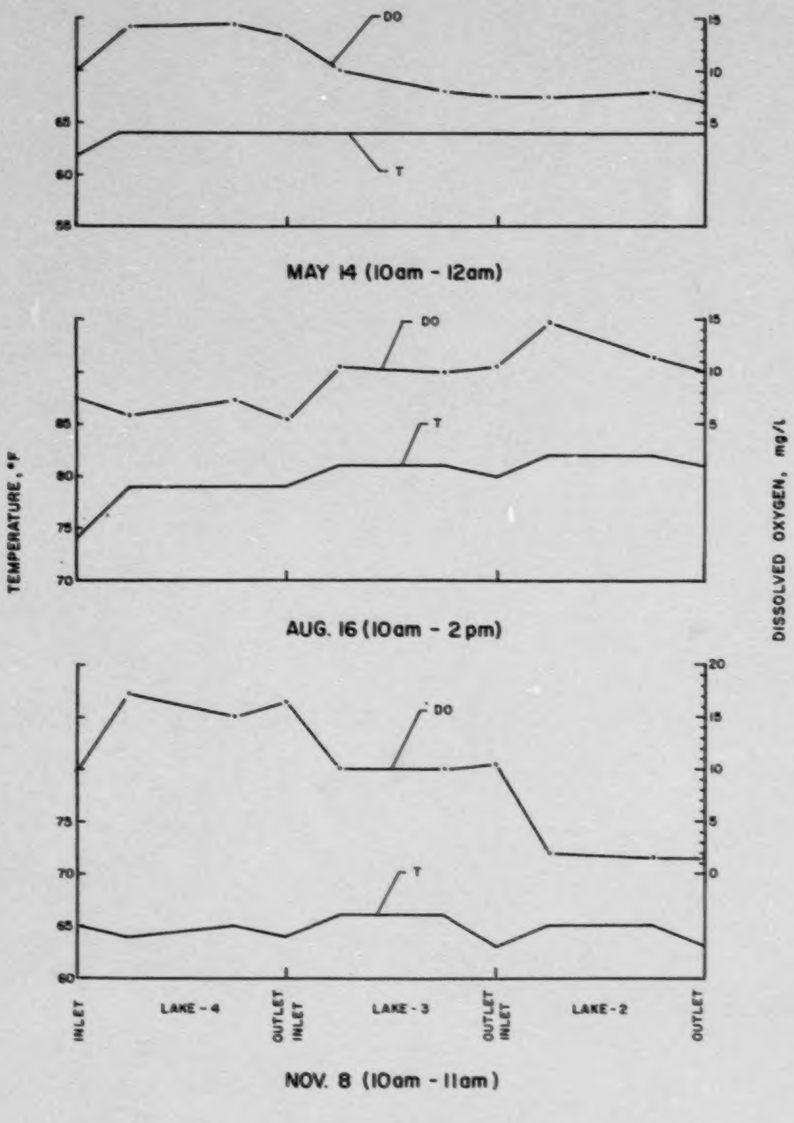

MAY 14 (10am - 12am)

AUG. 16 (10am - 2pm)

NOV. 8 (10am - 11am)

FIGURE 5

DISSOLVED OXYGEN CONCENTRATIONS IN LAKES 2, 3, AND 4

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period. Some of these readings likely contained a high percentage of mixed liquor and raw sludge that were not being effectively settled and removed because of the malfunctioning sludge pumping system. Figure 6 summarizes the average suspended (volatile and fixed) solids for each significant sample location for each sampling period. This chart shows that 90 per cent removals were obtained in the conventional treatment plant but were followed by a relative increase in the Oxidation Pond. This increase averaged about 30 ppm for the Oxidation Pond. Following percolation very low concentrations of both fixed and volatile suspended materials were found although again, in Lake 4, algal production increased volatile suspended solids. Some variation in suspended solids measurements of the raw, primary, and activated sludge is caused by the 20 per cent or more of the Oxidation Pond flow returned to the plant inlet.

The 10 ppm of non-volatile fixed suspended solids that has been pumped to the percolation area amounts to 60 lbs/day for the average flow rate of 0.72 mgd. It is estimated that this equals about 200 cubic feet of non-volatile material for the year. This material would fill less than 20 per cent of the voids in the top inch of percolation area surface soil. The need for semi-annual surface scarification in the percolation area is more likely caused by the clogging of the soil with volatile material or possible precipitated inorganic salts.

Suspended solids in the activated sludge mixed liquor averaged 6380 ppm as shown in Table 5 and the slight variation between readings for the quarterly periods correlated with COD percentages. The suspended solids were kept at this high level for control of foaming. Since November, suspended solids levels in the activated sludge process have been reduced to 2500 ppm and a cover for foam control of the activated sludge tank has been added. Foam is now returned with the waste sludge to the raw sewage inlet line and this operation has been accompanied by a slight increase in the effectiveness of ABS and COD removal. A level of about 6000 ppm suspended solids seems to be controlling factor for foam along with good sludge settleability for this plant. No apparent benefit other than foam control results from the high level of suspended solids.

During the four quarterly samplings, biochemical oxygen demand measurements were made at each of four stages of the treatment process. These measurements are summarized in Figure 7 to depict levels through the treatment process. BOD levels are shown to vary from an average of about 300 ppm in the raw sewage to a level of three ppm at the inlet to Lake 4. Secondary treatment process showed a capability for removal of 90 per cent of the BOD even at the very high suspended solids levels that were utilized. Over-all BOD removals equaled approximately 99 per cent. Levels of BOD found in the raw sewage were highest in February and declined at each successive sampling time during the year. Some of this decline was due to the operating difficulties with sludge pumping experienced in February. Of significance is the very low BOD

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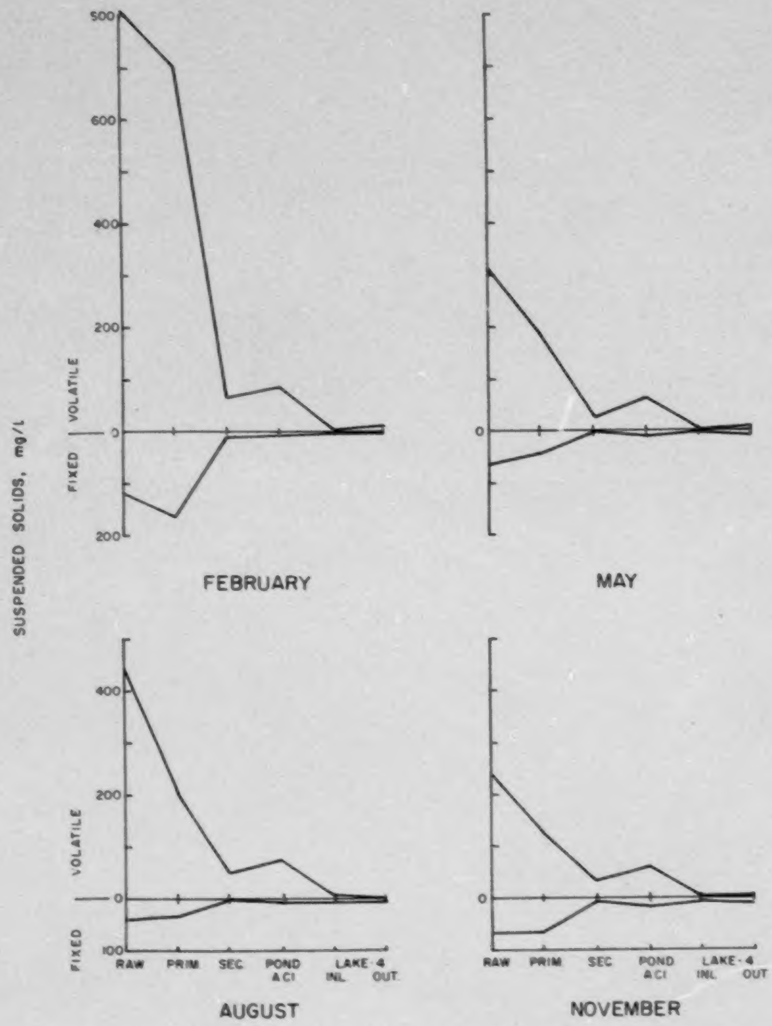

FIGURE 6

QUARTERLY RANGE OF SUSPENDED SOLIDS

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TABLE 5

QUALITY OF ACTIVATED SLUDGE

MIXED LIQUOR

Month	Susp. Solids mg/L.	% Settleable	Sludge Vol. Index	D.O. mg/L.
Feb	6140	84	13.5	1.0
May	5950	88	14.8	1.2
Aug	7330	97	13.2	1.1
Nov	6080	72	11.8	0.9
Year	6380	85	13.3	1.0

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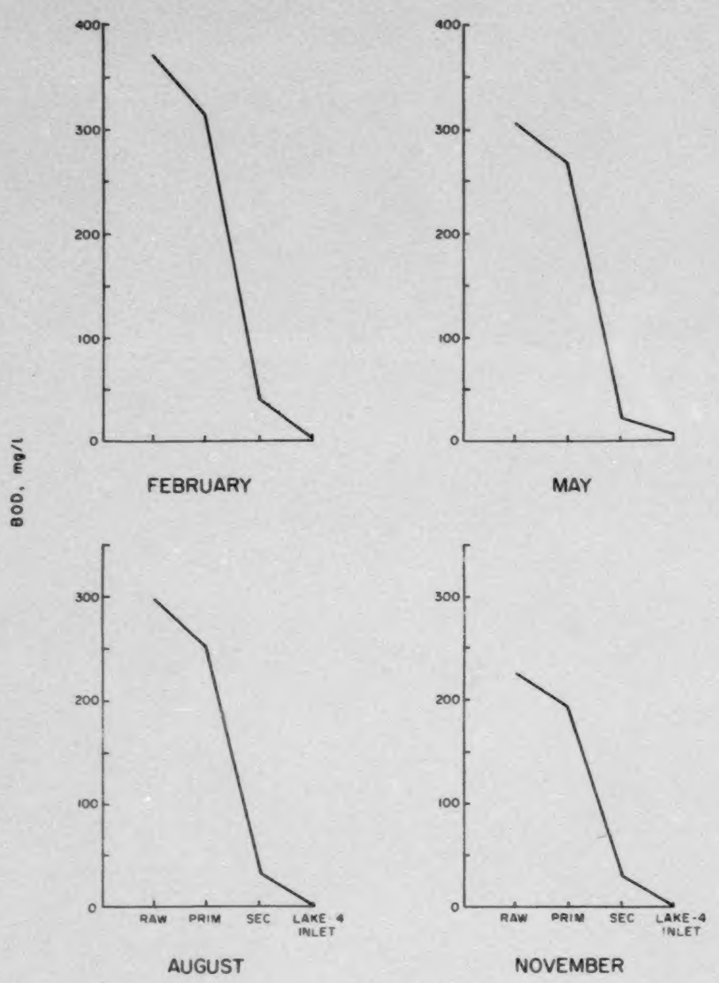

FIGURE 7

QUARTERLY RANGE OF BIOCHEMICAL OXYGEN DEMAND (BOD)

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level found at sample point X which is only 200 feet below the percolation area. The 2.5 ppm measured at this point in November indicates very good removal in the overloaded percolation process. The BOD in waters at sample point X are equal to the levels found at sample point Y which follows ground water travel of more than 2000 feet. In summary, normal removals seem to have been carried through the entire treatment process. Limitations were apparent in sampling the well because of shallow water and highly turbid samples which contaminated the BOD measurements from that source. The BOD of the final Lake 4 water would not be an indication of the water source.

Analyses for chemical oxygen demand were made at all eight original locations and also at intermediate points in the spreading area when significant changes were noted. Average COD results are shown in Figure 8. As with BOD determinations, higher levels were found in November and August. Occasional high readings from the grab samples obtained from either the raw sewage or the primary effluent caused greater variations in averages. These variations could be caused by supernatant or raw sludge return. Average levels at all other sampling points appeared to be quite consistent and showed over-all removals of about 95 per cent following percolation. The Oxidation Pond waters consistently showed a buildup from the levels found following activated sludge treatment possibly as a result of supernatant discharge directly to the pond. The percolation area showed a consistent ability to remove the COD carried in the Oxidation Pond effluent. While BOD results were not affected by a variation in activated sludge operation, the COD results seemed to be dependent upon the supernatant rate and the level of suspended solids carried in the mixed liquor. The chlorination did not greatly affect either the BOD or COD results. The two sample points X and Y showed COD levels that varied with underground travel. Following the November sampling period, suspended solids in the activated sludge process have been reduced to 2500 ppm with some decrease in COD levels. COD in the final waters entering Lake 4 does represent one of the characteristics that could identify the source of the reclaimed water.

A conductivity record of plant influent and Lake 4 indluent was obtained during February. In May a record of plant inlet was again obtained. These readings show conductivity changes from an average of 1500 micromhos to as high as 2000 micromhos for an occasional period of one hour due most probably to softener bachwash operations. Conductivity readings for the Lake 4 inlet were very consistent at levels of 1300 micromhos and show some change with the arrival of runoff in mid-February. Measurements of total dissolved solids by evaporation correlate well with conductivity. Total dissolved solids results are plotted in Figure 9. The wide variation in measurements for an individual sampling period are due to rainy periods. Variations between quarterly sampling periods for any individual station can be explained by entry of runoff or by concentration of salts through evaporation. Variations between sampling locations show a slight decrease in dissolved solids through the

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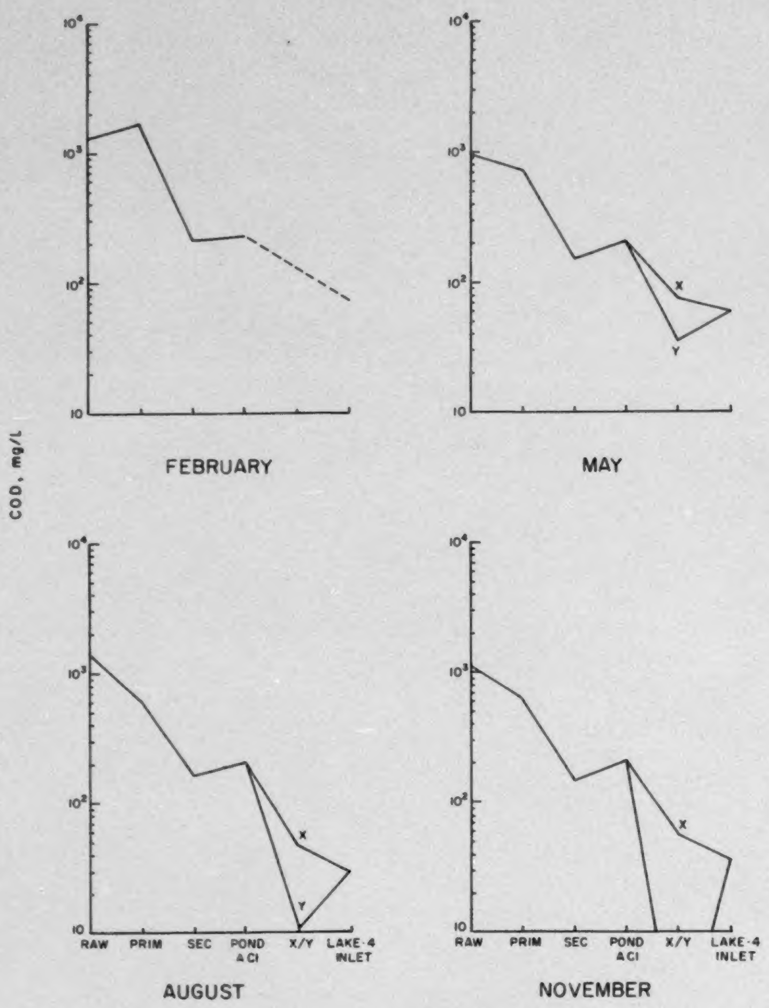

FIGURE 8

QUARTERLY RANGE OF CHEMICAL OXYGEN DEMAND (COD)

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activated sludge process and also a decrease in the percolation process. Solids reduction through the percolation process is, however, decreasing with time. The dissolved solids in the potable water averaged 750 ppm and in the Sampling Station 6 well water dissolved solids ranged from 460 to 660 ppm.

Measurements of alkalinity and pH have been graphed in Figure 10. Measurements in February were made in the field. All others were made in the laboratory. Greater ranges are apparent in the field measurements. All of the lakes show increased pH readings due to algae growths. The degree of alkalinity removal is also seasonally dependent on photosynthesis. The potable water delivered at Santee has a pH in the range of 7.5 to 8.5 and an alkalinity of about 120 ppm. Alkalinity of the natural ground water is 50 ppm.

Complete chemical analyses of all waters at all eight stages in the reclamation process were obtained for each quarterly period. Composites were used for Stations 1, 2, and 3. Results of these analyses have been plotted as milliequivalents per liter in Figures 11 and 12 except for boron, fluoride and silica. The loss of ammonium, potassium and calcium through the process is apparent. Calcium is apparently dropping out as calcium carbonate or phosphate in the oxidation pond and as the carbonate, phosphate, or sulfate in the percolation area. Figure 12 also shows great changes taking place for bicarbonate alkalinity. Reductions in this constituent can be attributed to the above precipitation as hardness and to utilization by algae. The concentrating effects of the lakes due to evaporation are emphasized in August by changes in the sodium and chloride ions. The sodium and chloride ions show similar stability at the various treatment stages except for a small loss of sodium following percolation that was apparent during the February and May operating periods. This could be attributed to some ion exchange taking place in the calcium type soils. Results for Lake 4 Inlet sampling point in August and November indicate that this soil capacity for exchange of sodium is exhausted. This point may be significant in explaining the loss of percolating capacity. Potassium and ammonia are also shown in Figure 11 and the loss of these nutrients is indicated as being almost complete following the percolation process. The water in Well B has a sodium ratio of about 50 per cent compared with sodium percentages of about 57 per cent before and after percolation. The well water has a much lower total ion concentration than percolated waters. As with the flow summary, ground water from a chemical standpoint can not be credited with any great affect on the percolating water.

The measurements of fluoride and nitrate do not greatly affect ion balances since maximum concentrations are about two ppm for each. The fluoride concentrations in Lake 4 are at the potable water level of 0.4 ppm. Measurements of boron show peak readings of about 1.0 ppm and final levels of 0.6 to 0.8 ppm in Lake 4. Silica concentrations varied between 16 and 30 ppm for all stages in the reclamation process with little change from the 19 to 28 ppm found in the raw sewage.

The complete nitrogen cycle including nitrates, nitrites,

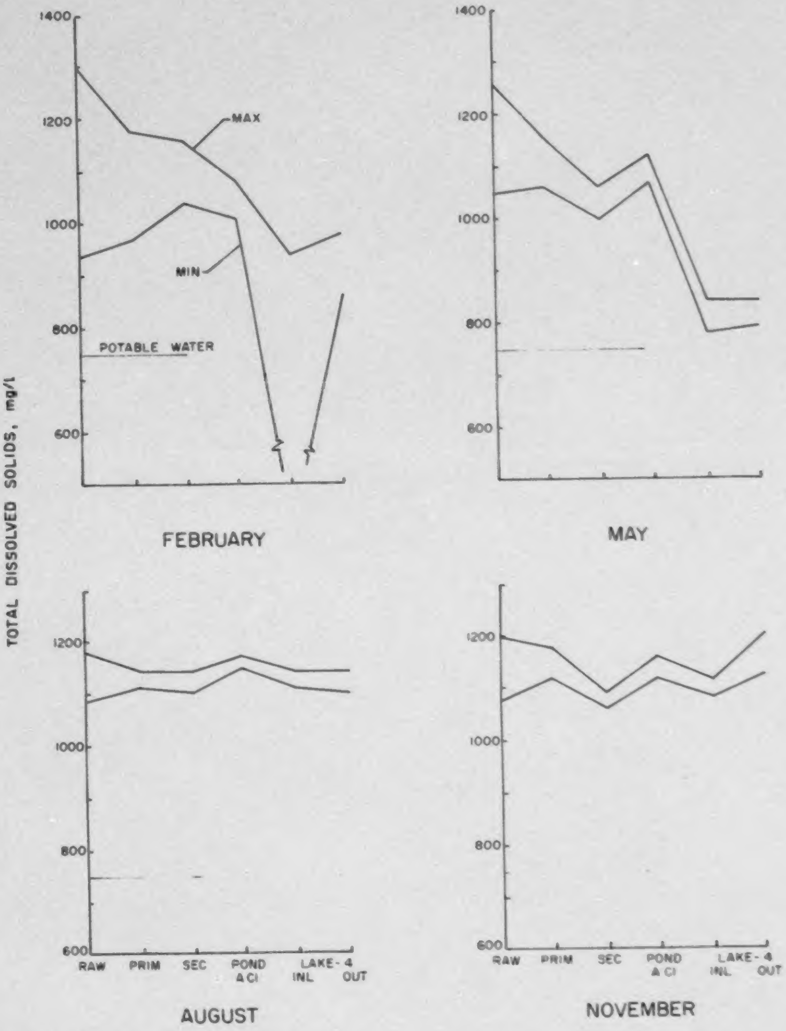

FIGURE 9

QUARTERLY RANGE OF TOTAL DISSOLVED SOLIDS (TDS)

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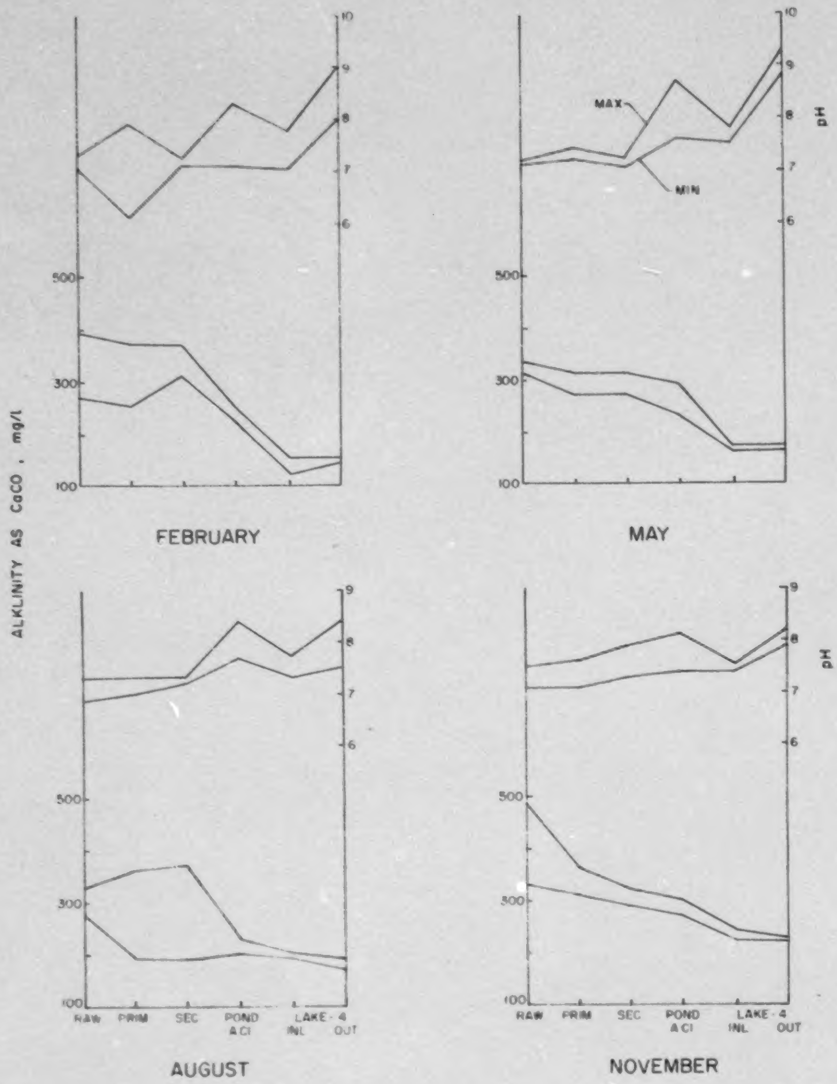

FIGURE 10

QUARTERLY RANGE OF ALKALINITY ($CaCO_3$) AND pH

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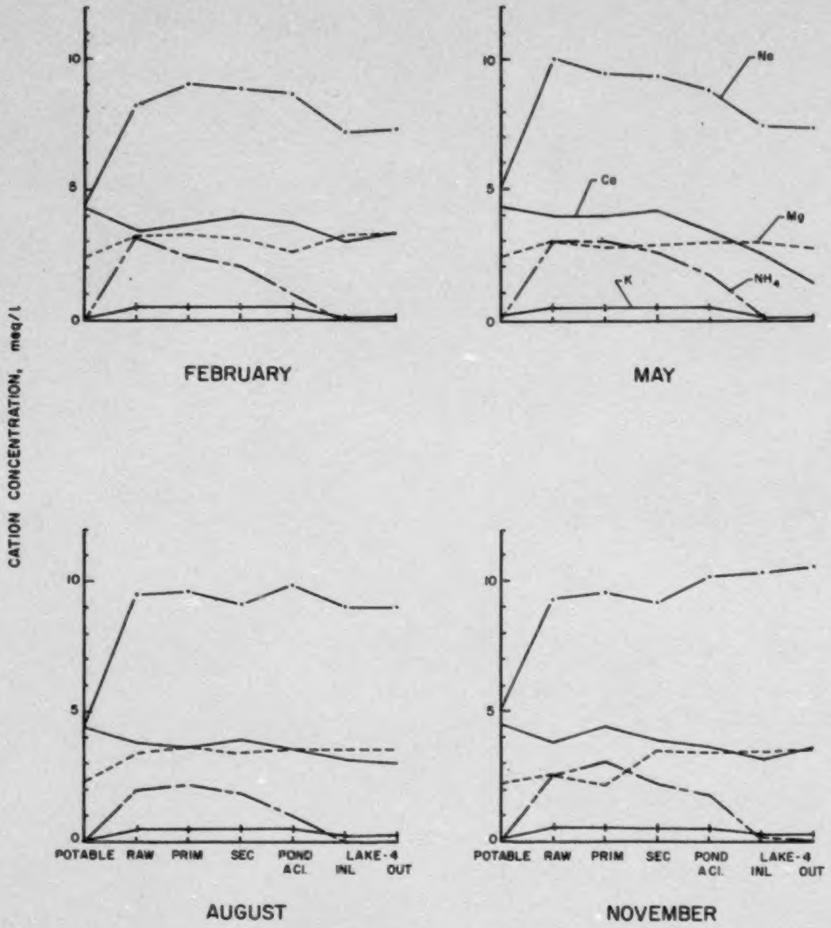

FIGURE 11

QUARTERLY RANGE OF Ca, K, Mg, N_2, AND NH_4 CATION CONCENTRATIONS

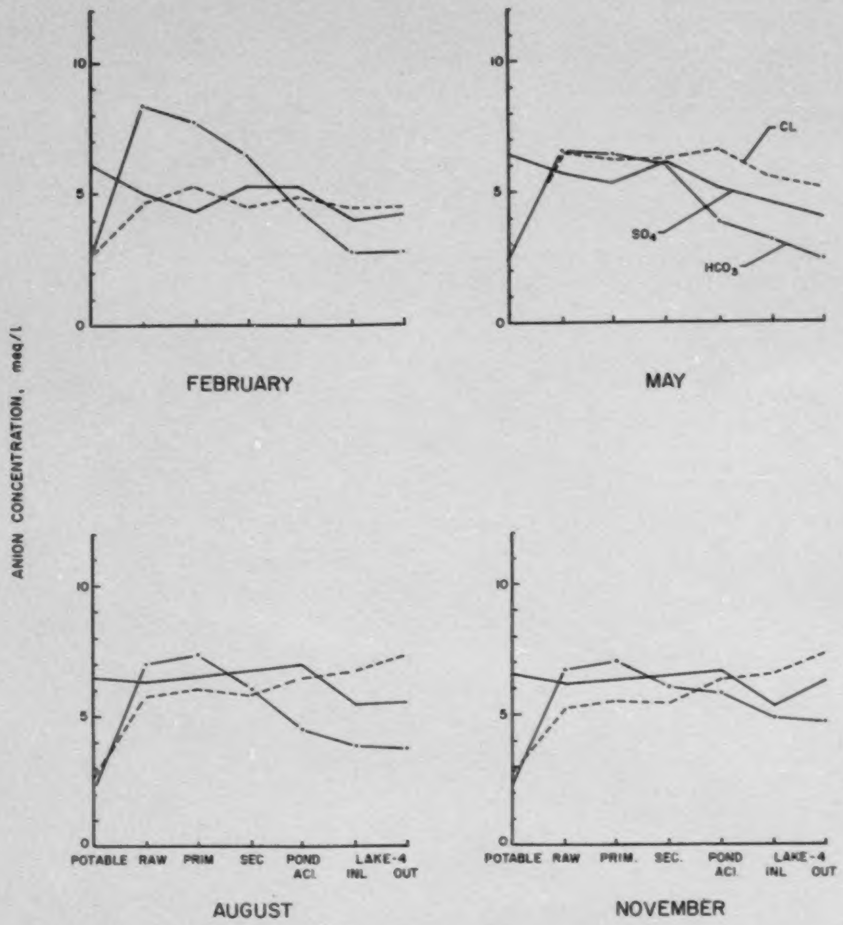

FIGURE 12

QUARTERLY RANGE OF Cl, HCO_3, AND SO_4 ANION CONCENTRATIONS

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ammonia and organic nitrogen, is plotted in Figure 13. Nitrite nitrogen is insignificant in all samples. Effective treatment for complete removal of organic and ammonia nitrogen is shown to be the percolation process, although very significant removals occurred prior to this phase. Analyses of water at location X showed 8 to 12 ppm of ammonia nitrogen while analyses for location Y showed only 0.1 ppm or less.

All measurements of phosphate and synthetic detergents (ABS) have been plotted as Figure 14. Basically, control of synthetic detergents has been due to the activated sludge process which removes on the average about 50 per cent, and the percolation process which has removed on the average an additional 25 per cent. It is quite likely that the percolation process has removed ABS by an absorptive property of the soil, since samples obtained in November in the stream below the percolation area (location X) now show the same levels as the water being percolated. Waters obtained 2000 feet downstream show levels of about 20 per cent of that being percolated, indicating that soil absorptive capacity has not been reached for all of the basin. At a soil absorptive capacity of ten micrograms per gram, it is estimated that some ABS will continue to be removed by absorption for about three years. Well B from Station 6 showed a significant trace of ABS in February. Little benefit in ABS control is apparent in either the Oxidation Pond or Lake 4. The plot of phosphate measurements shows that the percolation area accounts for one-half the reduction, although some widely variable benefits are derived from the activated sludge process. Phosphate levels found at Station 6 again indicate that, after the early determinations in February, flushing of the ground water basin occurred. Measurements of phosphate were made from filtered and unfiltered samples in August and November. These show from 1.0 to 7.0 ppm of phosphate tied up in suspended material. Phosphate levels at sample point Y are equal to those in the water entering Lake 4.

Measurements of phenol made at all stations during the February test period showed an average concentration of .07 and .08 ppm only in the raw and settled sewage and it was concluded that the treatment process was completely effective in removing any phenol.

Radiological analyses for both alpha and beta activity were made during February and August. In February significant beta activity was measured in the waters at the inlet to the percolation area. This activity of 419 ± 18.2 micro-microcuries per liter was most likely due to heavy runoff that occurred at this time. All other beta activity levels ranged from approximately 16 to 90 micro-microcuries per liter. Generally no significant alpha activity was found.

Microbiological Quality

In accord with the plan to determine background information for the fate of virus in sewage, three different measurements of bacterial quality have been made. Originally it had been planned to sample for coliform, fecal coliform and fecal streptococci on a quarterly basis with a sampling frequency of each four hours from each of the eight sample points. Limitations in the mobile laboratory supply and incubator capacity reduced the number of samples so that each sample

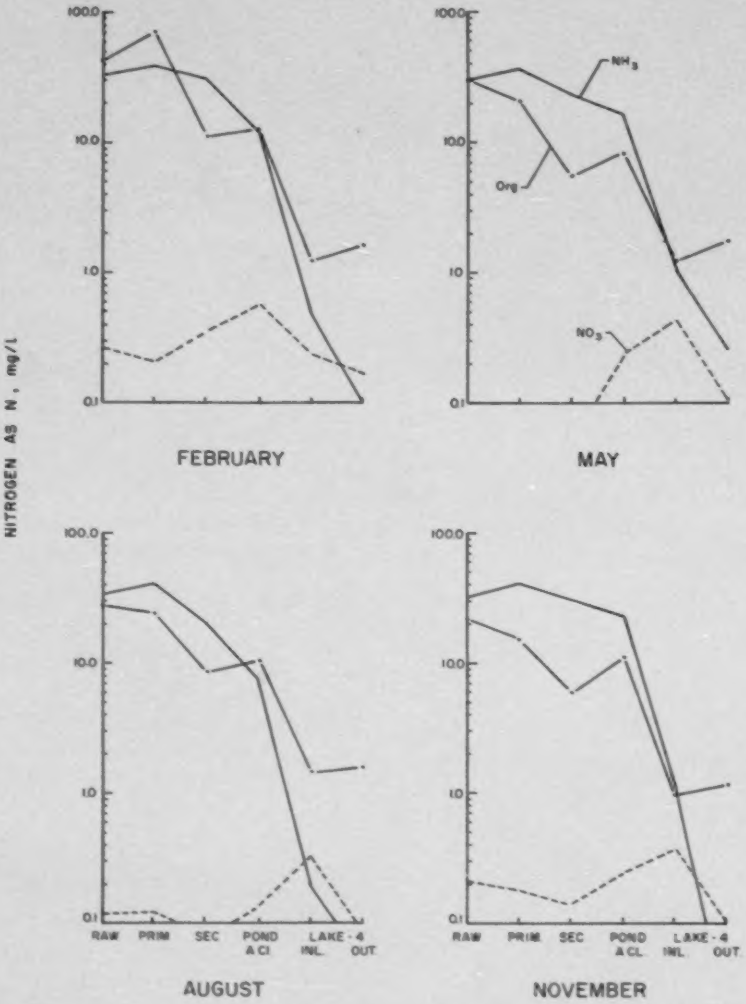

FIGURE 13

QUARTERLY RANGE OF NITROGEN CONCENTRATION

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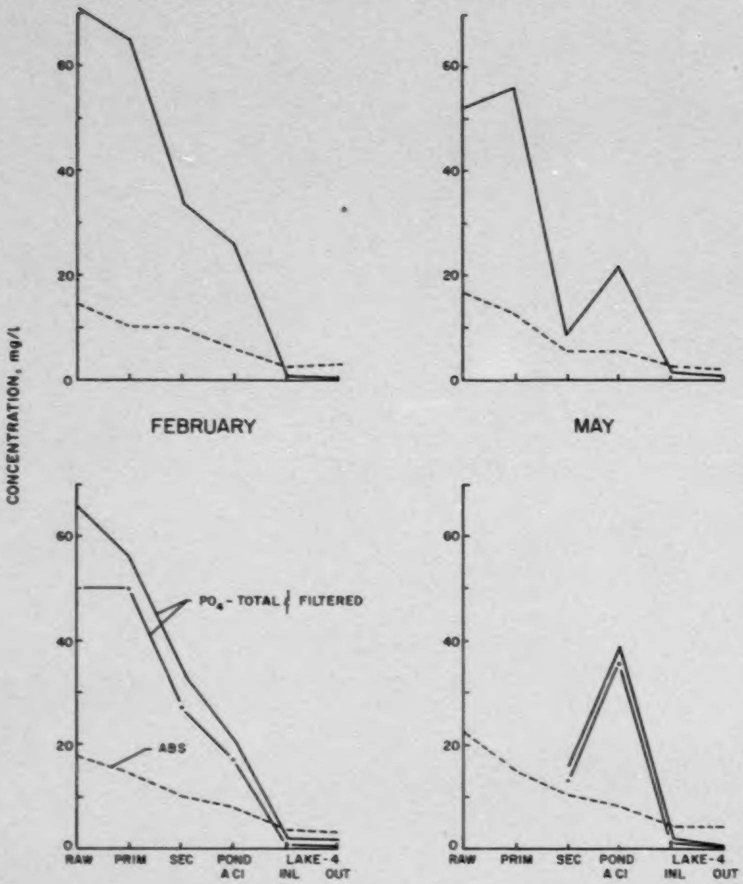

FEBRUARY

MAY

AUGUST

NOVEMBER

FIGURE 14

QUARTERLY RANGE OF ORTHOPHOSPHATE AND APPARENT ABS CONCENTRATIONS

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point was sampled at the four-hour interval for only one week and confirmations for fecal coliform were limited to the incubator capacity in the mobile laboratory. Following the February sampling further consolidation of the numbers and types of bacterial determinations were made with some stations averaging less than a dozen samples while two stations were sampled each four hours for a total of 84 times during the two-week period. Frequency of fecal coliform determinations was varied to utilize the maximum capacity of the incubators available. Median MPN's for coliform and fecal coliform show a diurnal variation for only the raw and primary effluent stations. The usual variation between early morning and later periods is apparent, and the 11 o'clock sampling time utilized in the virus study for comparative purposes by the San Diego County Department of Public Health is apparently adequate when flows are considered. Figure 15 and Table 6 show median counts for all determinations made for both coliform and fecal streptococci during each of the quarterly periods. Table 6 also shows the per cent of coliforms which were fecal coliforms. Fecal coli percentages were calculated for only those samples on which counts were made. The most significant change in these percentages is apparent following chlorination where fecal coliform ratios of less than 10 per cent are found. Coliform counts at Lake 4 outlet are less than those at the inlet, while the median fecal coli counts remain about the same at all points following chlorination (1.e. always less than two per 100 ml.) The effectiveness of chlorination is decreased during August at a time when maximum temperatures in the pond occurred. This could be explained by the more rapid tie-up of chlorine by nitrogen.

A second bacteriological record has been obtained through weekly samples obtained at 11:00 a.m. on Mondays and each week since March 5th. This set of samples shows a good consistency with the quarterly test periods utilizing the State mobile laboratory.

Figure 15 also indicates some possible seasonal variation for the bacteriological parameters found in the Lake 4 inlet. The higher results in May are likely related to increased runoff following February rains.

Fecal streptococci, measured by the California State mobile laboratory, included incubation in tubes, whereas the San Diego County laboratory utilized the MF method, using KF agar. In addition, The San Diego laboratory ran a plate count using KF agar in comparison with the MF procedure. The correlation between these counts was good for the higher counts.

A plot of the maximum and median MPN along with the MPN that is exceeded 20 per cent of the time is shown in Figure 16. The coliform concentration of the water after percolation was consistently greater than that of the water spread on percolation beds. Some tests run on aftergrowths show that the Oxidation Pond waters chlorinated to a MPN of less than two per 100 ml did not recover in a bottle environment and that the MPN of waters from the stream decreased with time as did the MPN of the waters of Lake 4. Several MPN determinations for sample locations X and Y failed to indicate any differences from the average MPN for waters in the stream. Ground water sampling procedure has been limited to samples that are grabbed from the surfacing waters.

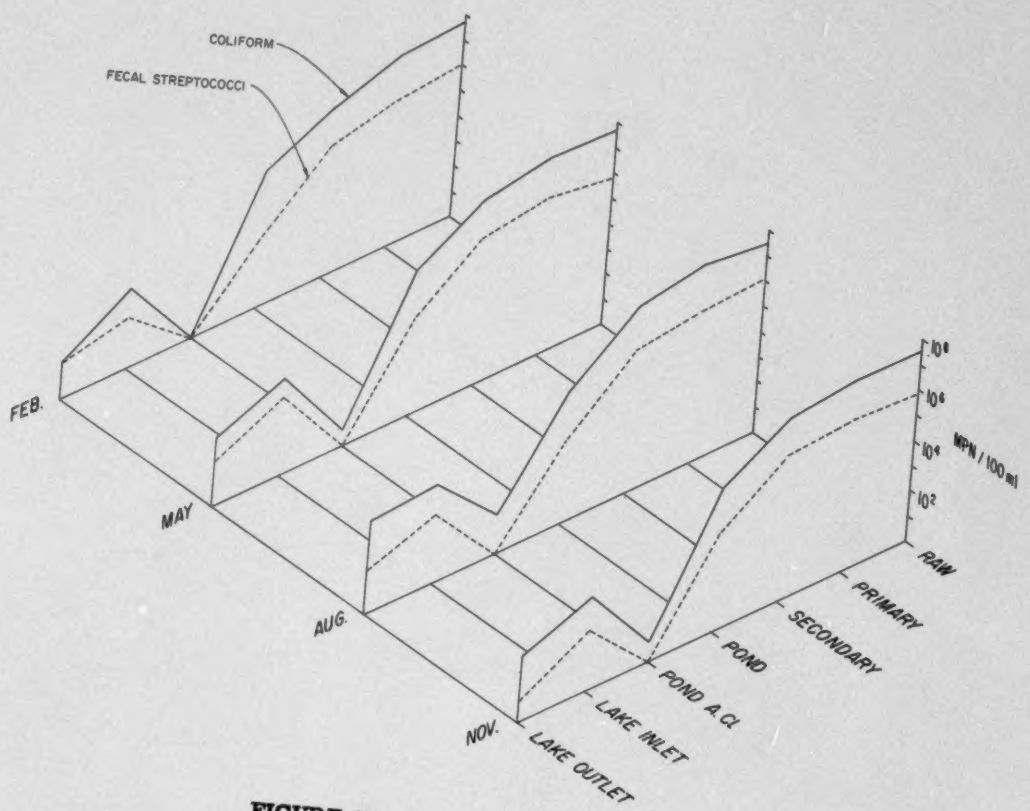

FIGURE 15

QUARTERLY RANGE OF THE MEDIAN COUNTS OF COLIFORM AND FECAL STREPTOCOCCI

TABLE 6

MEDIAN MPN'S/100 ml

COLIFORM - FECAL COLIFORM - FECAL STREPTOCOCCI

		FEB.	MAY	AUG.	NOV.	Annual Aug. County Health Dept.
RAW	Coliform	54×10^6	49×10^6	49×10^6	33×10^6	79×10^6
	% Fecal	39 (12)	25 (6)	27 (13)	40 (13)	42
	Fecal Strep	1.3×10^6	$.79 \times 10^6$	13×10^6	$.79 \times 10^6$	1.2×10^6
PRIM.	Coliform	54×10^6	79×10^6	64×10^6	49×10^6	49×10^6
	% Fecal	26 (9)	26 (23)	28 (12)	55 (20)	47
	Fecal Strep	$.79 \times 10^6$	1.7×10^6	1.1×10^6	$.79 \times 10^6$	1.3×10^6
2ND	Coliform	4.9×10^6	23×10^6	23×10^6	23×10^6	5.4×10^6
	% Fecal	52 (13)	41 (36)	40 (42)	51 (52)	44
	Fecal Strep	$.13 \times 10^6$	$.79 \times 10^6$	$.46 \times 10^6$	$.79 \times 10^6$	$.27 \times 10^6$
POND B.CL.	Coliform	310×10^3	780×10^3	$.80 \times 10^3$	790×10^3	240×10^3
	% Fecal	21 (8)			37 (28)	21
	Fecal Strep	790	7000	1300	9200	3700
POND A.CL.	Coliform	<2	4.5	39	4.5	4.5
	% Fecal					
	Fecal Strep	<2	<2	<2	<2	0
LAKE #4 INLET	Coliform	1300	7900	4900	4900	1600
	% Fecal	13 (13)				0.8
	Fecal Strep	130	1300	450	220	640
LAKE #4 OUTLET	Coliform	23	460	4900	390	120
	% Fecal			3 (10)	<18	1.7
	Fecal Strep	22	49	45	4.5	10

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1. Fecal Coliform is shown as a per cent of the coliform count and no. of sample determinations are shown in parentheses.

2. No percentage can be shown for several locations because of the large number of samples for which no MPN was established.

3. The S. D. Co. Dept. of Public Health made analyses on an 11 am sample each Monday since 3-4-62. An M.F. count was made for Fecal Strep.

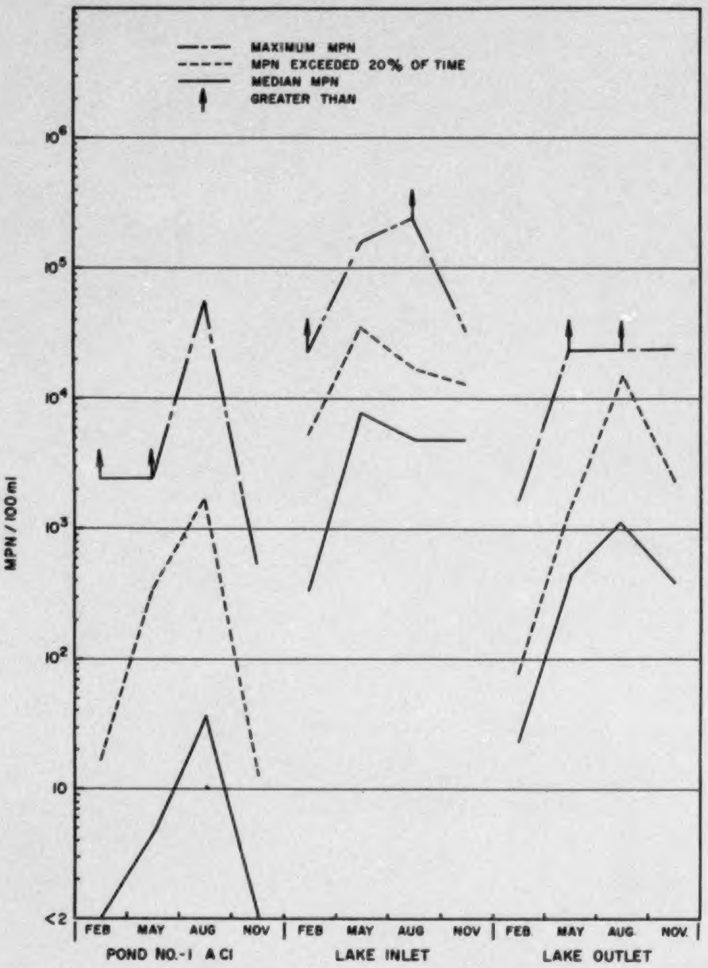


FIGURE 16

COLIFORM QUALITY OF CHLORINE-TREATED WATERS

Virology

Since July, 169 samples for the determination of viruses have been collected at the regular Santee sample stations. Over one-half of these samples have been processed by differential centrifugation following removal of the liquid sample from the swabs. A few identifications have been started using inoculation into primary monkey kidney and human amnion tissue cultures, but the large portion of samples have remained in the deep freeze while the staff was trained in specific virologic procedures. All determinations of viruses at Santee will be related to coliform, fecal coliform and fecal streptococci concentrations obtained from grab samples at the beginning or end of the 48-to-72-hour swab immersion period. To assist in evaluating the relation of the Santee community health with that of the total San Diego area, a swab sample of San Diego raw sewage has also been obtained. Some additional advantage may result from the virus study since the Sabin oral polio vaccines were introduced into the community during this virus study.

Biological Studies

The purpose of the biological studies at the Santee Recreation Project has been to obtain a working knowledge of the ecology of aquatic organisms in the Santee lakes. This should provide a basis for comparison under future operational procedure changes, and perhaps indicate what the optimal procedures should be.

The results of the first year's work have been largely descriptive.

The phytoplankton population in the Oxidation Pond was composed of relatively few genera containing very large numbers of individuals, with Chlorella the dominant genus. The different genera fluctuated greatly throughout the year, and at times an optimal population for the healthy operation of an oxidation pond was not attained. This usually resulted in a decided decrease in the dissolved oxygen concentration. Benthic organisms in the Oxidation Pond consisted almost entirely of gnat larvae. There were no fish in the lake, but small numbers of shore birds and waterfowl were present.

In Lake 4, although the phytoplankton represented many genera with low individual counts, there were occasional blooms of some of the genera. There was not, however, a marked or continuous dominanace by any particular genus. Benthic organisms were generally scarce, although large numbers of snails were found. Gnat larva were about one-quarter as abundant as they were in the Oxidation Pond. A successful fishery was established in Lake 4, and fish also were present in large numbers in Lakes 2 and 3. There was an abundance of aquatic and semi-aquatic bird life. One species the American coot (Fulica americana), interfered with recreation to some extent because of the nuisance it created.

In all of the lakes zooplankton was seldom visually apparent. At one time, however, there was a heavy concentration of bryozoan statoblasts which were not only picked up in plankton samples, but also were easily observed from shore. Fortunately, the blue-green algae never became plentiful during the year, although three genera were identified.

It may be concluded from the biological studies on this first year that the system is operating quite satisfactorily, that there are no serious plant and animal nuisances and that it is possible to provide a good recreational fishery.

Recommendations for future work include additional effort in identifying and enumerating the zooplankton and benthic fauna populations in order to complete the inventory of the life forms present, a transfer of emphasis from the descriptive phase to the ecological aspects of the lakes as far as chemical and physical relationships are concerned and a continuous monitoring of the project to prevent or to control problems before they become serious. It is also recommended that biological studies be continued in conjunction with any future experimental manipulations in the operation of the lakes.

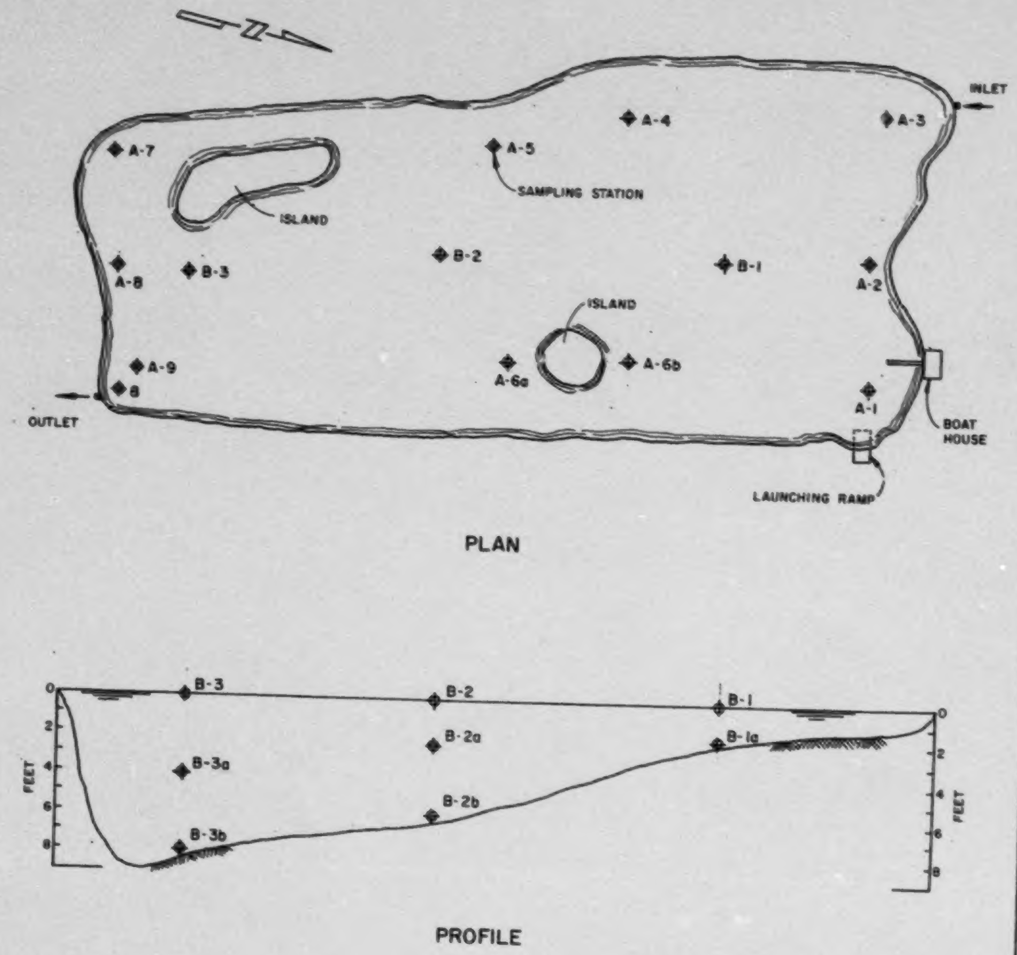
Although the sampling program included all four lakes and their associated waterways, almost all of the work was confined to the Oxidation Pond and Lake 4 during this first year. The sampling period for the first nine months of 1962 paralleled the program noted earlier in that work was done during a two-week period in February, May and August. Beginning in October, a more intensive program of plankton sampling and selected chemical and physical analyses in Lake 4, only, was inaugurated in addition to the two-week November period. Work on the fisheries aspects proceeded according to need without a rigid schedule of regularly spaced sampling.

Phytoplankton Populations

The composition and relative abundance of phytoplankton populations were checked during the four quarterly sampling periods at Station 4 in the Oxidation Pond prior to chlorination of the discharge, at Station 5, located just ahead of the percolation area, but after chlorination, and in Lake 4 at Stations 7 and 8, (Figure 1). All were surface grab samples, except at Station 5, which originated in the Oxidation Pond at a depth of about three feet. Sampling was performed four times within a two-week period at an interval of from two to five days, in each of the quarterly sampling periods, except at Station 5 where, in the fourth quarter, sampling was done only on the single day of November 6. The samples for the first three quarters were counted by personnel of the Testing and Control Division Water Laboratory of the City of San Diego.

The more intensive sampling, which began in October, consisted of eight stations in Lake 4, including ones near the bottom at depths varying from two to eight feet and trial sampling at two intermediate stations (B-1 through B-3b, Figure 17). Samples were taken at 1 p.m. on each of five different days in October. In November and December the sample collecting was changed to include possible diurnal variations by sampling at 5 a.m. and 4 p.m. In addition to the collection and counting of plankton samples, dissolved oxygen concentrations and temperature readings were also taken corresponding to each of the plankton samples.

As shown in Table 7, the Oxidation Pond, which was sampled at Station 4, contained eighteen genera belonging to four general


N
INLET
A-3
A-4
A-5
SAMPLING STATION
A-7
ISLAND
A-8
B-3
B-2
B-1
A-2
ISLAND
A-9
B
A-6a
A-6b
A-1
OUTLET
BOAT HOUSE
LAUNCHING RAMP
PLAN
B-3
B-2
B-1
B-3a
B-2a
B-1a
B-2b
B-3b
FEET
0
2
4
6
8
PROFILE

NOTE: VERTICAL SCALE GREATLY EXAGGERATED

FIGURE 17

LAKE 4, SAMPLING STATIONS

SANTEE RECREATION PROJECT
SANTEE, CALIFORNIA

TABLE 7

List of phytoplankton genera identified in samples collected at Stations 4 and 5, in the Oxidation Pond and in Lake 4 during the four quarterly Sampling periods and the intensive Sampling in 1962. Santee Recreation Project, Santee, California

		Oxidation Pond		Lake 4
Group	Genus	Station 4 (BC1)	Station 5 (AC1)	Stations 7&8
BLUE-GREEN	Anacystis			X
	Gomphosphaeria			X
	Microcystis*			X
	Oscillatoria	X	X	X
GREEN	Actinastrum			X
	Ankistrodesmus	X	X	X
	Chlorella	X	X	X
	Chlorococcum	X	X	X
	Closterium	X	X	X
	Coelastrum	X	X	X
	Dictyosphaerium			X
	Golenkinia			X
	Kirchneriella			X
	Lagerheimia	X	X	X
	Micractinium			X
	Oocystis	X	X	X
	Pediastrum			X
	Scenedesmus	X	X	X
	Schroederia	X	X	X
	Sphaerocystis	X	X	X
	Staurastrum			X
	Tetradesmus			X
	Tetraedron			X
	Uronema			X
FLAGELLATES	Carteria	X	X	X
	Chlamydomonas	X	X	X
	Chlorogonium			X
	Chromulina			X
	Chroomonas			X
	Cryptomonas			X
	Euglena	X	X	X
	Glenodinium	X		
	Hetromastix			X
	Lepocinclis		X	X
	Nephroselmis			X
	Phacotus		X	
	Phacus			X
	Polytomella	X		X
	Trachelomonas			X
DIATOMS	Cyclotella			X
	Diatoma			X
	Gomphonema			X
	Melosira			X
	Navicula	X		X
	Nitzschia	X		X
	Stephanodiscus			X
	Synedra		X	X

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* The name Microcystis is recorded separately to honor the integrity of a particular investigator's records. This form would otherwise be lumped with Anacystis in this report, following Palmer.

groups of algae as follows: Blue-green - 1, Green - 10, Flagellates - 5 and Diatoms - 2. Five genera were already present when the lake was first sampled on February 6, 1962, but the relatively common genus Nitzschia never appeared in samples until November 6th.

The total count of algae during the general 1962 sampling program ranged from 23,800 per ml on February 13th to 728,646 per ml on November 6th (Table 8). Contributing most heavily to the November 6th high, and also to the generally high fourth quarter, was the genus Chlorella, which increased greatly throughout the season. This genus reached its peak of 551,128 organisms per ml on November 13th when water temperatures were from 14 to 18° F. Cooler than in August (Figure 18). Second and third in high single date counts were Ankistrodesmus at 172,480 per ml on May 14th and Oocystis which reached a peak of 158,400 per ml on August 16th and a slightly lower peak at the beginning of November, but otherwise never reached an abundance greater than 14,000 per ml. Chlamydomonas reached a brief peak on May 14th, while Sphaerocystis was high on August 14th. The remaining genera were relatively never abundant. Diatoms were especially rare, occurring in only two samples prior to November, and then reaching a maximum count of only 2,400 organisms per ml.

Although Euglena only reached a count of 45,000 organisms per ml, it should be noted that this represents about twice the volume of the Chlorella at its highest (551,128/ml) since algae organisms vary significantly in size.

Changing dominance among the genera is shown in Table 9. The figures used are the totals of the four individual counts of the given genus within each quarter. The position among the first four was assigned not alone on total numbers produced during the quarterly sampling, but also because the organism remained in the same order all month or for most of the month, changing to the next lower position during the rest of the month.

Although *Euglena* was dominant in the Oxidation Pond in the first quarter, a place it often holds in raw sewage lagoons, this genus dropped to fourth position in the second and fourth quarters, and was not among the first four in the third quarter. *Chlorella*, on the other hand, began as a low second in the first quarter and then reached marked dominance, at first place, throughout the rest of the year. *Chlamydomonas* occupied second place in May, but was never among the first four in the other quarters. *Oocystis* was second in dominance in the third and fourth quarters.

In regard to the Oxidation Pond, it can be concluded that the free-floating algae population resembles a low-loaded oxidation pond, with high numbers of individuals belonging to relatively few genera.

The samples of the Oxidation Pond water *after chlorination* were taken from water which had been mixed through the pump and piped up to Station 5 at the percolation area. The genera found in samples from Station 5 were distributed among the major groups as follows: Blue-green - 1, Green - 9, Flagellates - 5 and Diatoms - 1 (Table 7). The number of genera in each major group is nearly the same as in the pre-chlorination samples, but the composition within groups is different.

30a

TABLE 8

Algal counts of samples taken at Station 4 (before chlorination), Oxidation Pond
during the four quarterly Sampling periods in 1962
Santee Recreation Project, Santee, California

Genus	February				May				August				November			
	2/6	2/8	2/13	2/15	5/8	5/10	5/14	5/17	8/7	8/9	8/14	8/16	11/6	11/8	11/13	11/15
BLUE-GREEN																
Oscillatoria	400	600							4,400			880	1,603			
GREEN																
Ankistrodesmus						5,280							7,214	12,825	8,016	6,412
Chlorella	8,000	3,000	2,000	7,400	68,400	121,360	128,480	131,120	120,560	200,640	63,360	26,400	420,038	517,031	551,128	304,608
Chlorococcum													36,871	11,222	7,214	5,611
Closterium											4,400					
Coelastrum												1,760				
Lagerheimia													801	3,206	2,404	1,603
Oocystis			100		5,200	8,800	7,920	880	9,680	6,160	14,080	158,400	133,867	8,817	11,222	8,016
Scenedesmus	200	200	100	200	2,400	10,560	4,400	2,640		880	10,560	880	52,904	42,483	28,856	7,213
Schroederia			200													
Sphaerocystis					8,400	14,960	19,360	16,720	14,080	7,920	58,080		5,611	2,404	1,603	801
FLAGELLATES																
Carteria						23,760										
Chlamydomonas					1,200	29,920	172,480	77,440	880		4,400	6,160	30,460	5,611	3,206	1,603
Euglena	23,600	24,000	21,200	45,000	1,200	10,560	14,960	9,680		2,640			36,873	4,809	15,229	11,222
Glenodinium									1,760							
Polytomella	600	400	200	400												
DIATOMS																
Navicula		+							380							
Nitzschia													2,404	1,603	801	801
TOTAL	32,800	28,200+	23,800	53,000	96,800	225,200	347,600	238,480	152,240	213,240	154,980	194,480	728,646	610,011	629,679	347,390

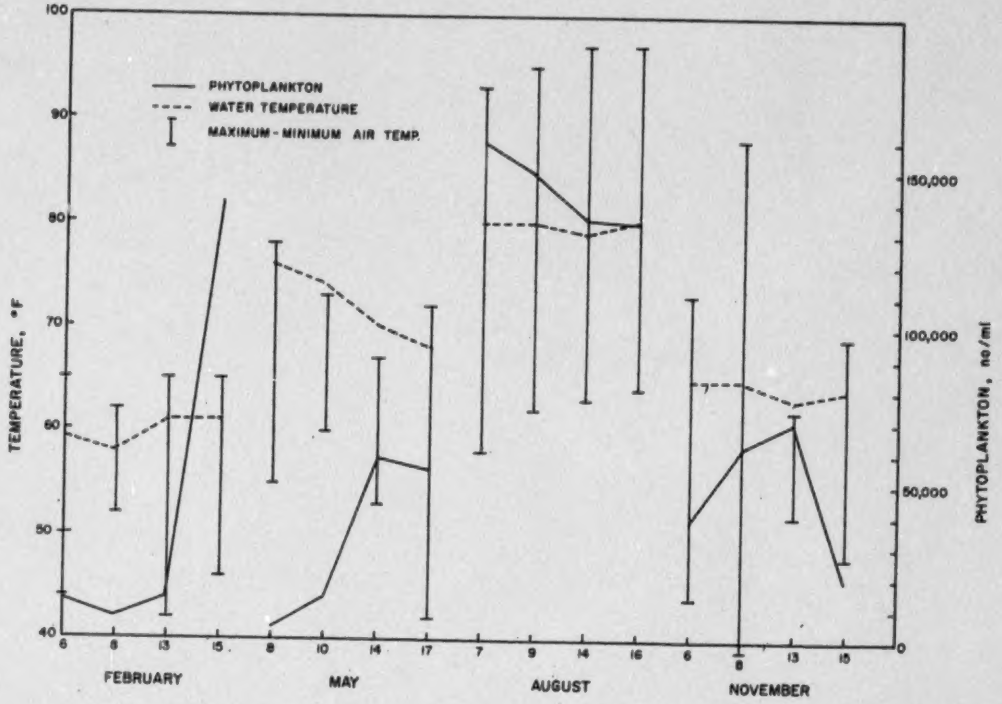

FIGURE 18

PHYTOPLANKTON COUNTS, WATER TEMPERATURES, AND MAXIMUM-MINIMUM AIR TEMPERATURES, SAMPLING STATION NO. 8, LAKE 4 OUTLET

SANTEE RECREATION PROJECT
SANTEE, CALIFORNIA

TABLE 9

The four most abundant genera of algae collected at the Oxidation Pond and Lake 4 during the four quarterly Sampling periods in 1962 Santee Recreation Project, Santee, California

Quarter		Oxidation Pond				Lake 4	
		Station 4 (pre-chlor.)		Station 5 (post-chlor.)		Stations 7 & 3	
		Genus	No/ml	Genus	No/ml	Genus	No/ml
First (Feb.)	1	Euglena	*113,600	**Euglena	624,600	Oscillatoria	4,900
	2	Chlorella	20,400	Chlorella	52,200	Chlorella	2,600
	3	Polytomella	1,600	Oscillatoria Scenedesmus	800 800	Polytomella	2,500
	4	Oscillatoria	1,000	(No others recorded)		Actinastrum Scenedesmus	1,500 1,500
Second (May)	1	Chlorella	449,360	Chlorella	691,200	Navicula	54,120
	2	Chlamydomonas	281,040	Sphaerocystis	258,240	Trachelomonas	28,960
	3	Sphaerocystis	59,440	Chlamydomonas	212,960	Euglena	9,740
	4	Euglena	36,400	Euglena	71,720	Micractinium	8,220
Third (Aug.)	1	Chlorella	410,960	Oocystis	235,840	Euglena	11,440
	2	Oocystis	188,320	Chlorella	225,280	Synedra	7,920
	3	Sphaerocystis	80,080	Sphaerocystis	105,600	Cryptomonas	7,040
	4	Scenedesmus	12,320	Scenedesmus	9,680	Navicula	6,160
Fourth (Nov.)	1	Chlorella	1,792,805	Chlorella	509,015	Chromulina	51,301
	2	Oocystis	161,922	Scenedesmus	43,285	Nitzschia	15,228
	3	Scenedesmus	131,456	Oocystis	15,230	Chlamydomonas	11,221
	4	Euglena	68,133	Euglena	15,229	Cryptomonas	9,619

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[*] These figures are the sums of the individual counts within each quarter for the given genus.

[**] Inactive

The green alga genus Chroederia was not found, and the flagellate algae Glenodinium and Polytomella and the diatom algae Navicula and Nitzschia were each missing.

It is interesting to note, however, that three genera, the flagellates Lepocinclis and Phacotus and the diatom Synedra, were present here although not found in the pre-chlorination samples. This is probably because the pre-chlorination samples were taken from the surface while the post-chlorination samples were collected from water derived at a depth of three feet in the Oxidation Pond and presumably genera missed by the surface samples were picked up here.

Table 10 presents the abundance of the various genera on the different sampling dates in the four quarterly periods of 1962 for the chlorinated effluent from the Oxidation Pond. It also indicates when the different genera were first observed. In many respects Table 10 is similar to Table 8. Most of the genera in the samples from post-chlorination waters first showed up either at the same time they did in the pre-chlorination samples, or at least within only a few days later. The total count at Station 5 ranged from 95,800 per ml on May 8th to 617,223 per ml on November 6th. Data indicate that there were two peaks of abundance: mid-May and early November. As in the Oxidation Pond, the highest individual count was for the genus Chlorella at 509,015 per ml on November 6th. This genus was only slightly less abundant during mid-May. Second highest was Sphaerocystis at 202,400 per ml on May 17th, followed by Euglena, which was high throughout all of February. The only free-floating blue-green alga in the Oxidation Pond waters was Oscillatoria. It peaked at Station 4 at 4,400 per ml on

August 7th. Other genera seldom fluctuated much or reached prominent peaks.

Only five of the eighteen genera recorded from the Oxidation Pond were apparently destroyed by exposure to chlorine at a residual of from five to seven ppm. These have already been noted in the paragraph above which discusses group composition. Furthermore, a comparison of Tables 8 and 10 shows that one or more genera were apparently present in greater numbers following chlorination. For example, numbers of Euglena in samples from Station 5 in February represented an increase of from five to nine times their pre-chlorination abundance, although admittedly in a so-called "inactive" stage. Other genera which increased noticeably were Ankistrodesmus, Chlorella, Oocystis (4th quarter only) and Sphaerocystis.

Referring to Table 9 again, Chlorella was the dominant genus occupying either first or second place throughout the year. Euglena was dominant in the first quarter, dropped to fourth place in the second and fourth quarters, and was not found in the third quarter. This was similar to the pattern established by the pre-chlorination samples. Oocystis, Scenedesmus, Sphaerocystis, and Chlamydomonas each remained among the first four in one or more of the quarters. Over-all, there were only minor positional differences between Stations 4 and 5 for the Oxidation Pond.

Lake 4 presents a considerably different picture than the Oxidation Pond as far as the algae population is concerned. Referring again to Table 7 and to Tables 12, 13 and 14, it can be seen that Lake 4 contained at least 46 different genera. The majority of these were the

TABLE 10

Algal counts of samples collected from Station 5 (after chlorination), Oxidation Pond during the four quarterly sampling periods in 1962. Santee Recreation Project Santee, California

Genus	February				May				August				Nov.
	2/6	2/8	2/13	2/15	5/8	5/10	5/14	5/17	8/7	8/9	8/14	8/16	II/6
BLUE-GREEN													
Oscillatoria	400	400								880			
GREEN													
Ankistrodesmus													12,024
Chlorella	19,400	18,800	5,600	8,400	79,600	147,840	237,600	226,160	129,360	44,000	45,760	6,160	509,015
Chlorococcum													9,615
Closterium									1,760		3,520		
Cöelastrum					200								
Lagerheimia													3,206
Oocystis					1,000	2,640	880		2,640	102,960	7,040	123,200	15,230
Scenedesmus	200	200	200	200	3,200	12,320	4,400	1,760	1,760	2,640	3,520	1,760	43,285
Sphaerocystis					9,200	31,680	14,960	202,400	25,520		80,080		1,603
FLAGELLATES													
Carteria						7,920		2,640					
Chlamydomonas						25,520	98,560	88,880					8,016
Euglena	*121,600	*163,400	*179,600	*160,000	2,200	7,040	27,280	35,200					15,229
Lepocinclis					400								
Phacotus						12,320							
DIATOMS													
Synedra									880				
Total	141,600	182,800	185,400	168,600	95,800	247,280	383,680	557,040	161,920	150,480	139,920	131,120	617,223

* Inactive

Table 11

Algal counts of samples collected from Lake 4 during the four quarterly sampling periods in 1962. Santee Recreation Project, Santee, California

Genus	February				May				August				November			
	2/6	2/8	2/13	2/15	5/8	5/10	5/14	5/17	8/7	8/9	8/14	8/16	11/6	11/8	11/13	11/15
BLUE-GREEN																
Anacystis					80											
Gomphosphaeria					20											
Microcystis					60		880									
Oscillatoria	3,600	400	500	400												
GREEN																
Actinastrum	800	200	200	300												
Ankistrodesmus												1,760			1,603	
Chlorella			2,600				880		1,760			3,520				801
Closterium					20											
Coelastrum					20		880	880								
Dictyosphaerium	200	200														
Golenkinia						1,760						880				
Micractinium					300		2,640	5,280							1,603	
Oocystis			400			880										
Pediastrum		200	200		20					880		880				
Scenedesmus	200	600	400	300	40	880		880	1,760							
Schroederia									2,640	2,640						
Sphaerocystis					40	4,400										
Staurastrum	200															
Tetradesmus									2,640							801
Uronema										5,280						
FLAGELLATES																
Carteria								2,640								
Chlamydomonas					580	2,640	2,640								10,420	801
Chlorogonium							880									
Chromulina															38,476	12,825
Cryptomonas										7,040					5,611	4,008
Euglena		+	100		60		9,680			7,920		3,520			801	
Lepocinclis					20											
Phacus		+														
Polytomella	1,000	1,200	200	100												
Trachelomonas			100	+	1,680	7,040	12,320	7,920								
DIATOMS																
Cyclotella													801			
Diatoma										1,760						
Gomphonema													801	801		
Melosira		+														
Navicula		+			440		14,080	39,600	1,760	1,760	2,640					
Nitzschia													1,603	2,404	10,420	801
Synedra		+						880	3,520	1,760	1,760	880	1,603			
Total	6,000	2,800+	4,700	1,100+	3,380	17,600	44,880	58,080	14,080	29,040	4,400	11,440	4,808	3,205	68,934	20,037

32b

32c

Table 12

Algal counts of samples taken at Station B-1, Lake 4 during the October-December, 1962 intensive sampling period. Santee Recreation Project, Santee, California

	October - 1 pm					November						December				
	9	11	16	23	25	6 4 pm	7 5 am	13 4 pm	14 5 am	20 4 pm	27 4 pm	4 4 pm	10 5 am	10 4 pm	26 5 am	26 4 pm
GREEN																
Ankistrodesmus			801			6,412	3,206		801	2,404	10,420	12,825	4,809	4,008	1,603	1,603
Chlorella	2,399		801		1,603											
Chlorococcum								801	801		3,206	1,603				801
Kirchneriella										801	7,214		1,603	3,206	4,809	4,008
Scenedesmus		400	801	2,404	801	801		801			801	1,603	1,603	801		
Schroederia		1,200														
Tetradesmus											801					
Tetraedron		400														
FILAMENTOUS GREEN																
2-celled filament	5,597	2,399	6,412	10,420	15,230	8,817	6,412	3,206	801	801	17,635	8,817			2,404	2,404
FLAGELLATES																
Chlamydomonas		800		5,611	7,214	145,891	64,929				801	2,404	801	1,603	13,627	26,452
Chromulina							4,008	8,817	20,841							
Chroomonas	63,868	33,592	7,214	4,809						801	6,412	20,039	3,206	12,825	8,016	20,040
Cryptomonas	8,796	4,799	20,040	16,833				4,008	801	4,809	4,008	4,809	2,404	4,008	17,635	38,476
Euglena		800						801	1,603		801	1,603	801	4,809	801	
Hetromastix											32,865	297,393	44,880	12,024		1,603
Nephroselmis						4,008	1,603	8,016	4,809							
Phacotus	800															
DIATOMS																
Cyclotella		400														
Gomphonema		400														
Navicula				801	801											
Nitzschia	1,599	800	801	801	801	8,016	1.603	5,611	2,404	8,016	30,460	4,809	801			
Stephanodiscus													7,214	7,214	16,833	24,048
Synedra		800		1,603	801											
Total	83,059	48,790	44,084	43,282	27,251	173,945	81,761	32,016	32,861	17,632	115,424	335,905	69,131	50,398	65,722	119,435

TABLE 13

Algal counts of Samples taken at Station B-2, lake 4 during the October - December, 1962 intensive Sampling period. Santee Recreation Project, Santee California

	October - 1 pm			November						December				
Genus	16*	23	25	6 4 pm	7 5 am	13 4 pm	14 5 am	20 4 pm	27 4 pm	4 4 pm	10 5 am	10 4 pm	26 5 am	26 4 pm
GREEN														
Ankistrodesmus		801	1,603	1,603	2,404	3,206		1,603	16,032	13,627	7,214	8,016		
Chlorella	3,206	4,008	3,206											
Chlorococcum					1,603		801		1,603	4,008			801	801
Kirchneriella								801	4,008	4,008	1,603	4,809	2,404	2,404
Micractinium										801				
Scenedesmus	1,603		801		801		801	1,603	1,603		801			801
Schroederia	801													
FILAMENTOUS GREEN														
2-celled filament	4,809	6,412	5,611	6,412	5,611	8,817	3,206		12,024	6,412	2,404	1,603		1,603
FLAGELLATES														
Chlamydomonas	801	2,404	1,603	16,031	48,096		801		1,603	801	801	801	4,809	4,008
Chromulina					1,603	32,308	13,627							
Chroomonas		1,603				3,206		801	12,825	33,667	4,809	8,816	8,016	4,809
Cryptomonas	7,214	8,016	801				801	2,404	4,809	5,611	1,603	6,412	14,428	16,032
Euglena						2,404	801			2,404				
Hetromastix								1,603	40,881	255,650	36,871	22,444		
Nephroselmis					1,603	1,603	7,214							
DIATOMS														
Cyclotella										801	1,603	3,206		
Navicula	2,404	801												
Nitzschia	1,603	8,817	801	1,603	7,214	9,619	4,008	10,420	32,865	5,611				
Stephanodiscus											15,230	10,420	20,040	24,849
Total	22,441	32,862	14,426	25,649	68,935	61,163	32,060	19,235	118,253	333,403	72,939	66,527	50,498	56,108

* No Samples taken October 9 & 11, 1963.

TABLE 14

Algal counts of samples taken at Station B-3, Lake 4 during the
October-December, 1962 intensive Sampling period. Santee Recreation Project
Santee, California

	October - 1 pm					November						December				
Genus	9	11	16	23	25	6 4pm	7 5am	13 4pm	14 5am	20 4pm	27 4pm	4 4pm	10 5am	10 4pm	26 5am	26 4pm
GREEN																
Ankistrodesmus						1,603	1,603	2,404		2,404	9,619	8,817	2,404	4,008	1,603	
Chlorella	800	2,399	801	4,008	4,008											
Chlorococcum			801	801			801				1,603					
Kirchneriella											5,611	4,809		801	2,404	2,404
Lagerheimia											3,206					
Micractinium									801							
Scenedesmus	1,599	400	801	2,404	2,404	801	1,603			801			801			
Schroederia	2,399	800		801		801										
Sphaerocystis											2,404					
Tetradesmus						801					801					
FILAMENTOUS GREEN																
2-cell filament	7,196	10,797		6,412	5,611	4,008	5,611	4,008	3,206	4,008	13,627	4,008	2,404	4,008		2,404
FLAGELLATES																
Chlamydomonas		1,500		5,611		23,246	37,675		1,603		801	8,817	801	801	8,817	6,412
Chromulina							4,809	30,460	11,222							
Chroomonas	5,597	16,796		3,206						3,206	9,619	20,841	8,817	5,611	8,817	12,024
Cryptomonas	6,397	4,000	10,420	20,040				1,603		1,603	13,627	13,627	4,809	1,603	14,428	32,064
Euglena												801		801		
Hetromastix											45,691	222,043	32,064	27,254		
Nephroselmis							2,404	16,032	2,404							
Phacotus	800															
DIATOMS																
Cyclotella					1,603							801	1,603	801	801	
Navicula	800															
Nitzschia	1,599	800		801		7,214	8,016	8,016	1,603	2,404	36,045	3,206	801	801		
Stephanodiscus													7,214	16,032	40,881	25,651
Synedra	800			1,603												
Total	27,987	37,492	12,823	45,687	13,626	38,474	62,522	62,523	22,839	14,426	142,654	237,770	61,718	61,718	77,751	80,959

green algae represented by 20 genera. The flagellate type were represented by 13 genera and there were eight diatom genera and four blue-green genera. There was also one unidentified 2-celled green filamentous type. Most of the genera listed were found during the regular quarterly sampling periods, but the more intensive last quarter sampling picked up nine more genera. It may be seen from Table 11 that the total count for any one sampling date in Lake 4 ranged from 2,800 organisms per ml on February 8th to 68,934 per ml on November 13th. The highest genus count was 39,600 per ml on May 17th for the diatom Navicula, which also achieved third highest for the whole period with 14,080 per ml on May 14th. A newly appearing genus, Chromulina, was second highest with 38,476 per ml on November 13th.

Dominance by quarters in Lake 4 is shown in Table 9. Here, too, there is a striking difference between the Oxidation Pond and Lake 4. No one genus remained dominant or even at the same position among the four most abundant genera during the year. Only three genera, Cryptomonas, Euglena and Navicula appeared among the first four in two quarters, and in these cases their respective positions changed.

No particular cycles of abundance were noted among the algal populations in Lake 4 as compared with the Oxidation Pond although some seasonal differences are suspected by the presence or absence of certain genera. Eighteen genera were found only in the first six-month period, including all of the blue-green algae. Sixteen genera were found only in the second six-month period. The first appearance

The lower station, B-3 ranged from 12,823/ml on October 16th to 287,770/ml on December 4th (Table 14). The highest figure for each station occurred on December 4th as a result of a sudden sharp rise in number of Hetromastix which first appeared on November 27th and disappeared again on December 10th. Among the genera which had reached such high peaks of abundance in Lake 1, e.g. Chlorella (551,128/ml), Chlamydomonas (172,480/ml) and Oocystis (158,400/ml), only Chlamydomonas also reached a high count in Lake 4 (145,891/ml on Nov. 6), although the genus Hetromastix, observed in Lake 4 only during the intensive samplings, also reached a high count (297,393/ml) on December 4th. Some of the genera first revealed in the intensive sampling were Nephroselmis on November 6th, Tetraedron on November 11th, Kirchneriella on November 20th and Stephanodiscus on December 10th. Others were Chlorococcum, Lagerheimia, Chroomonas, Phacotus and an unknown filamentous green alga in the form of a two-celled filament. The latter was present at nearly every station at both the surface and the bottom. It reached a peak of 17,635/ml at the surface in the 4 p.m., November 27th sample--a count considerably higher than many of the other genera which were recorded.

There does not seem to be a very great change in abundance of organisms linearly from the inlet to the outlet of Lake 4 as far as the surface samples are concerned, although the trend in total counts appears to be from highest at the inlet end to lowest at the outlet end. The opposite trend was evident, however, on three of the sixteen sampling dates.

of the year in the Santee area. There may be an optimum for this factor, too, as various research has showed, and this may work antagonistically as far as temperature is concerned.

The alkalinity records plotted in Figure 19 show an inverse relationship between abundance of phytoplankton and calcium carbonate alkalinity in Lake 4. This is even more apparent in Figure 21 which presents the data for the Oxidation Pond, showing great similarity to a true oxidation pond. The decrease in alkalinity caused by increased algal activity indicates normal functioning in both lakes, although the degree of change was limited since the lakes were deeper than the average oxidation pond.

Records of pH in Lake 4 showed the expected increase with increased numbers of algae except in August when other factors may have interfered. In the Oxidation Pond, however, the gross visual correlation, as exemplified by Figure 21, is quite apparent, as is the relationship between pH and alkalinity. At no time did the pH in Lake 4 reach extremes which would inhibit algal growth, but in the Oxidation Pond the relatively high pH, up to 8.9 corresponded to a decrease in the total algae count.

In Lake 4, the abundance of phytoplankton is inversely related to the concentration of ammonia nitrogen, one of the nutrient materials in the influent waters, (Figure 20). This relationship also generally holds true with the Oxidation Pond waters (Figure 22). Ammonia nitrogen is probably used chiefly by algae. The same two tables also show the relationship between phytoplankton and both orthophosphate and apparent ABS. There appeared to be little relationship

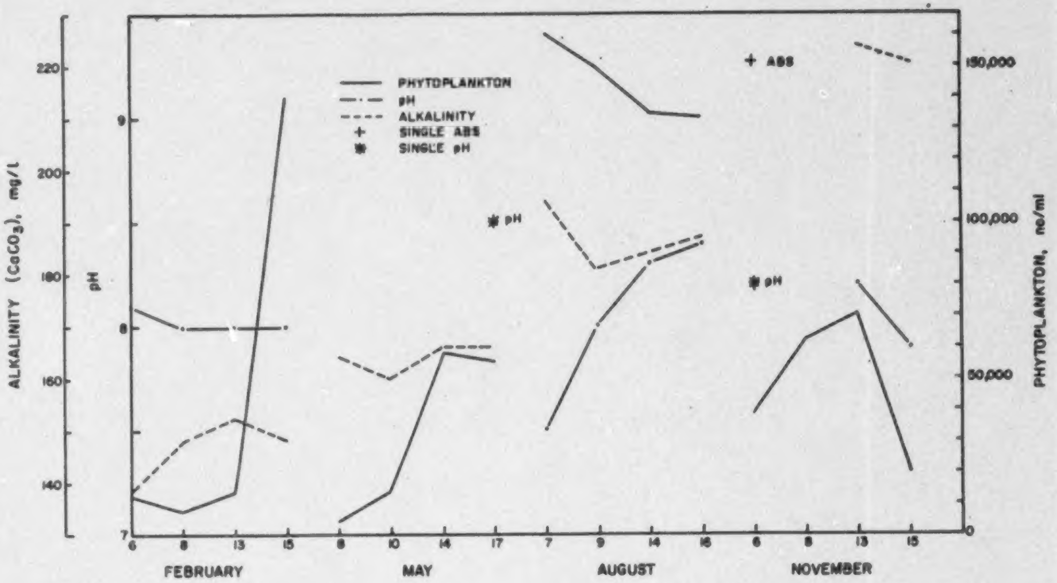

FIGURE 19

PHYTOPLANKTON COUNTS, ALKALINITY AND pH
AT SAMPLING STATION NO. 8, LAKE 4 OUTLET

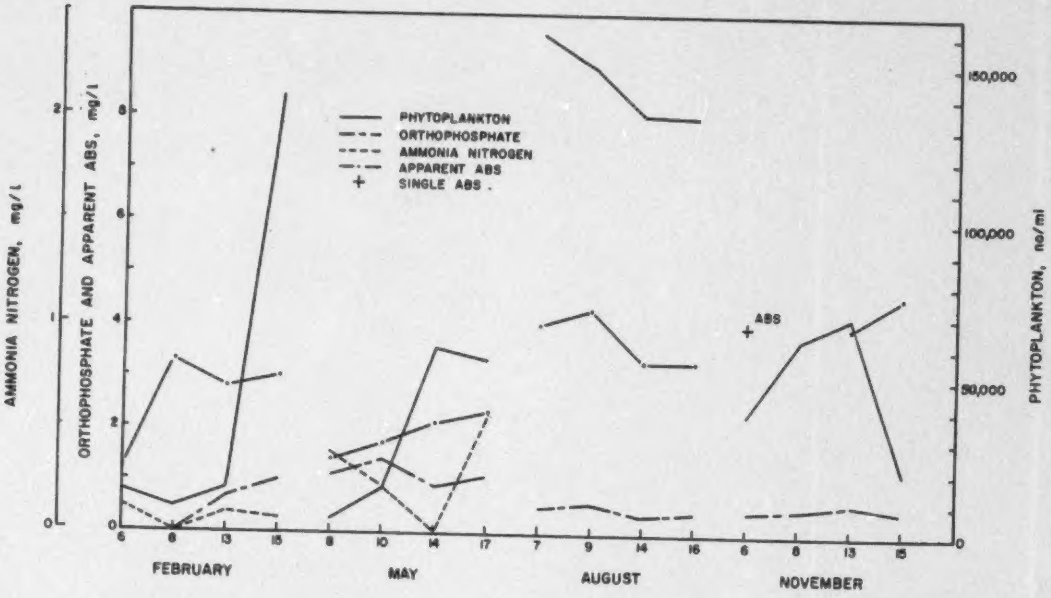

FIGURE 20

PHYTOPLANKTON COUNTS, APPARENT ABS, ORTHOPHOSPHATE AND AMMONIA NITROGEN AT SAMPLING STATION NO. 8, LAKE 4 OUTLET

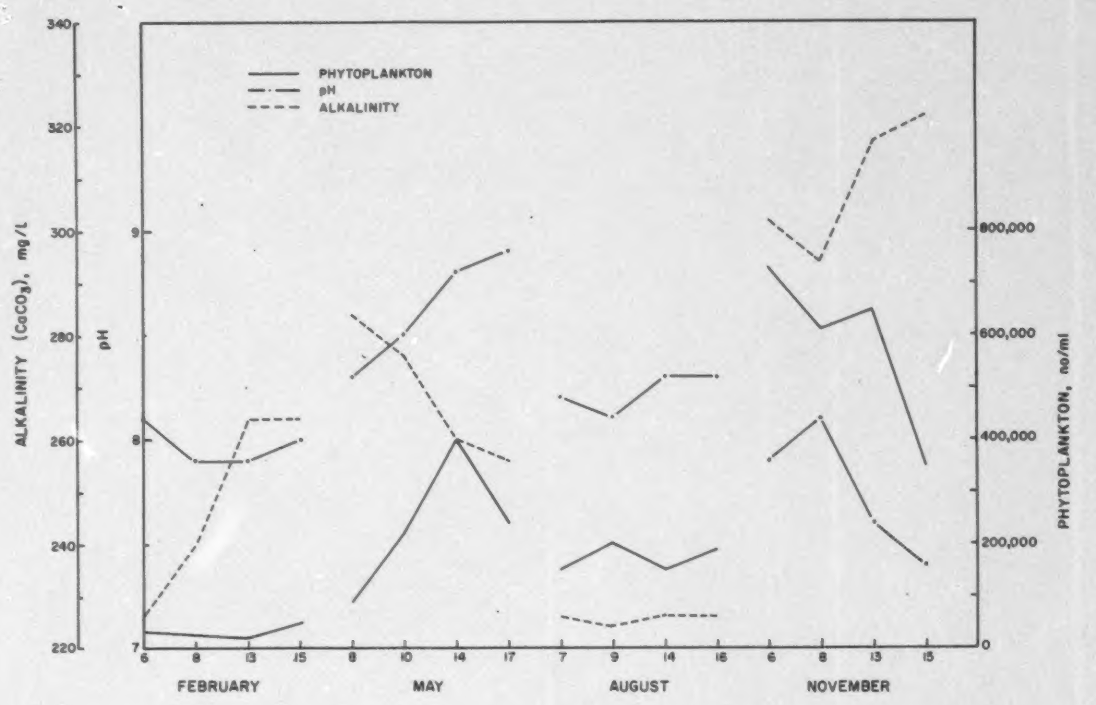

FIGURE 21

PHYTOPLANKTON COUNTS, ALKALINITY, AND pH (BEFORE CHLORINATION) AT SAMPLING STATION NO. 4, OXIDATION POND

SANTEE RECREATION PROJECT
SANTEE, CALIFORNIA

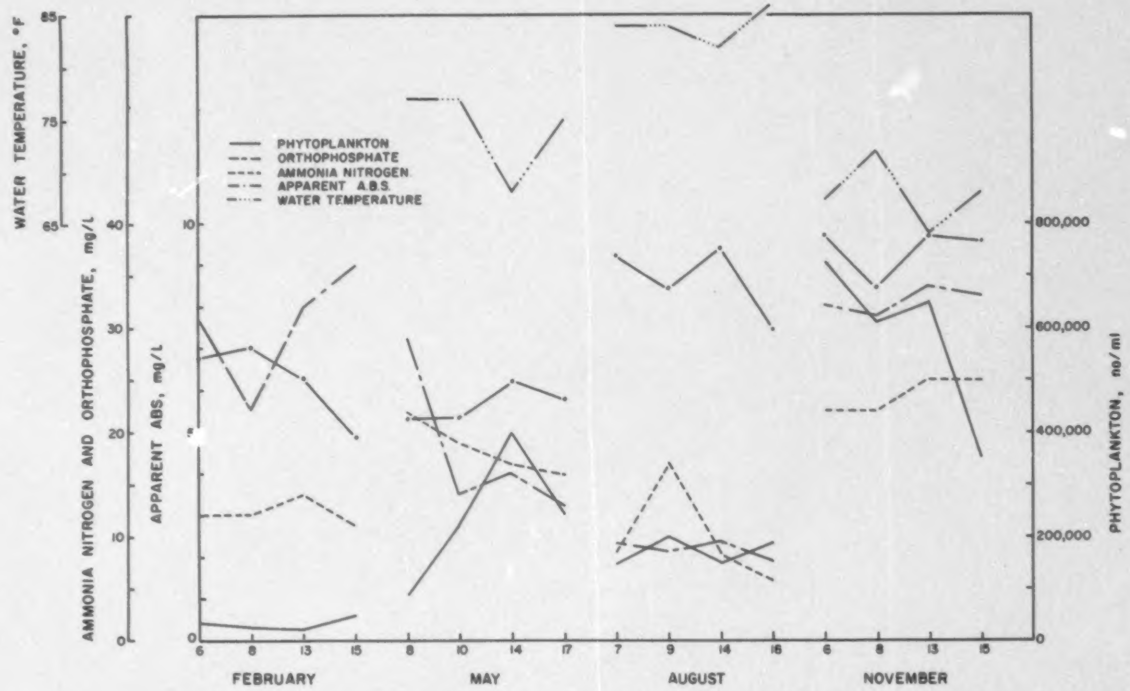

FIGURE 22

PHYTOPLANKTON COUNTS, WATER TEMPERATURES, APPARENT ABS, ORTHOPHOSPHATE AND AMMONIA NITROGEN (BEFORE CHLORINATION) AT SAMPLING STATION NO. 4, OXIDATION POND OUTLET

SANTEE RECREATION PROJECT
SANTEE, CALIFORNIA

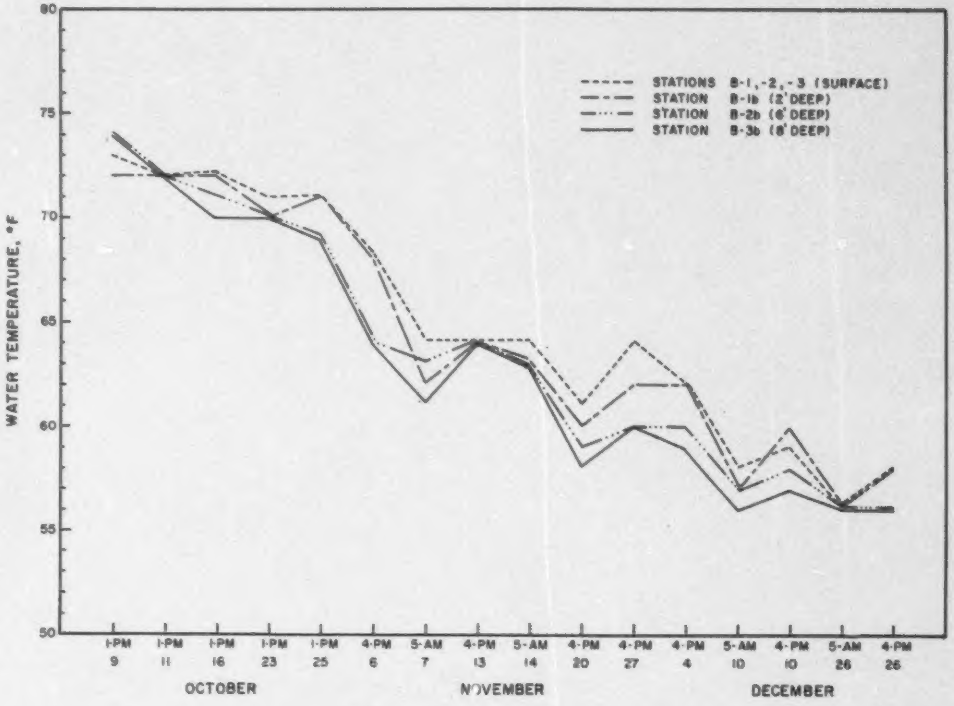

FIGURE 23

WATER TEMPERATURE IN LAKE 4

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SANTEE, CALIFORNIA

2 ppm between surface and bottom at about the time of uniform temperatures, although at other periods the spread reached up to 12 ppm (Figure 24), because of the increase in algae noted below. At the same time, however, at each point of nearly complete mixing: October 11th, 23d, November 13th and 14th and December 26th, an increase of phytoplankton occurred either simultaneously or shortly thereafter (Figure 25). There was a lag of up to two weeks following the November 13th mixing, while on October 11th, only the count of algae at the eight foot deep station showed an increase. Conversely, the peak count of 319,026 organisms per ml, which took place on December 4th, coincided with the maximum difference between top and bottom temperatures. This was undoubtedly due to other factors which were not measured during this period.

Figure 26 presents the order of relative abundance of the various genera during each week of the intensive sampling period. Counts are averages for the lake and do not necessarily show any single sample dominance. During any given set of four succesive weeks, in only two instances was any one genus dominant more than once. One of these was Cryptomonas for two weeks in October. The other was Hetromastix for three weeks between November and December. In two or three cases, the dominant genus exceeded 50 per cent of the total: Chroomonas at 78 per cent in the second week of November and Hetromastix at 80 per cent in the second week of December. Chlorella and Scenedesmus, while present, never reached even fourth place in dominance although this is frequently the case in ponds undergoing active oxidation. Chlamydomonas, however, which often succeeds the

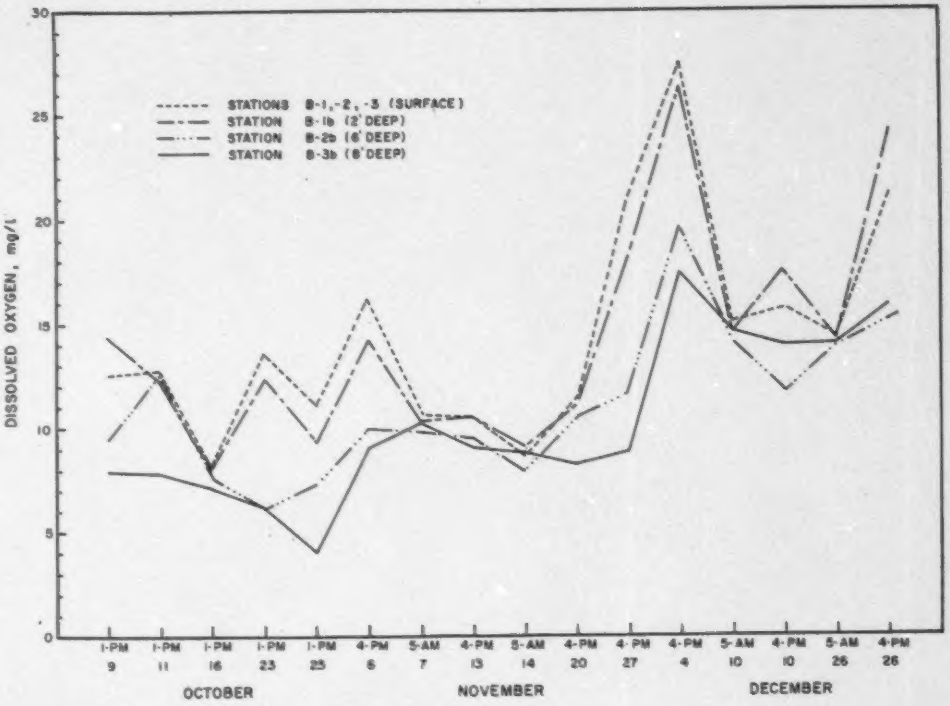

FIGURE 24

DISSOLVED OXYGEN CONCENTRATIONS IN LAKE 4

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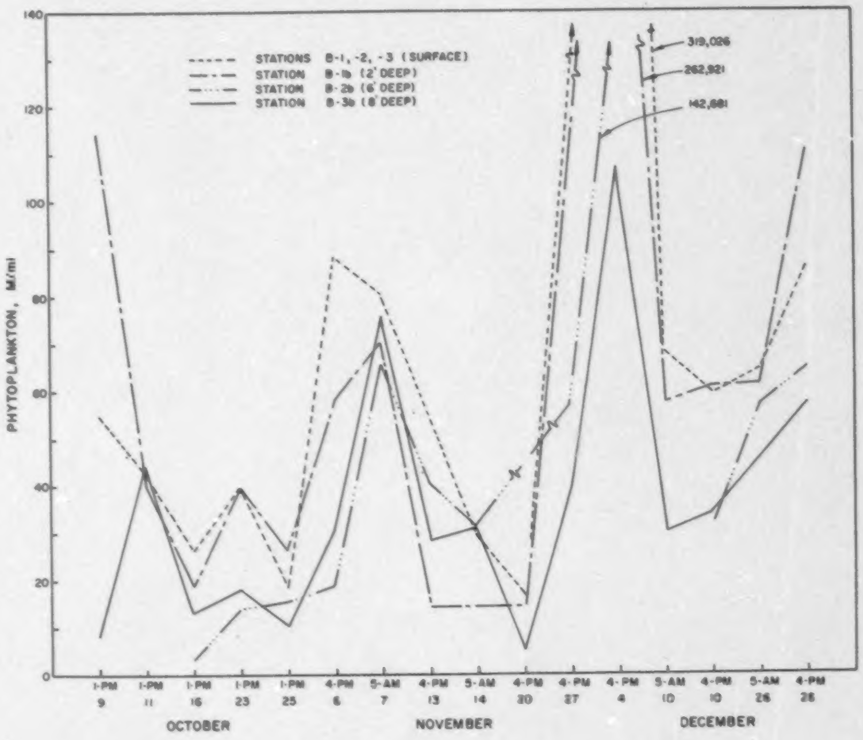

FIGURE 25

PHYTOPLANKTON IN LAKE 4

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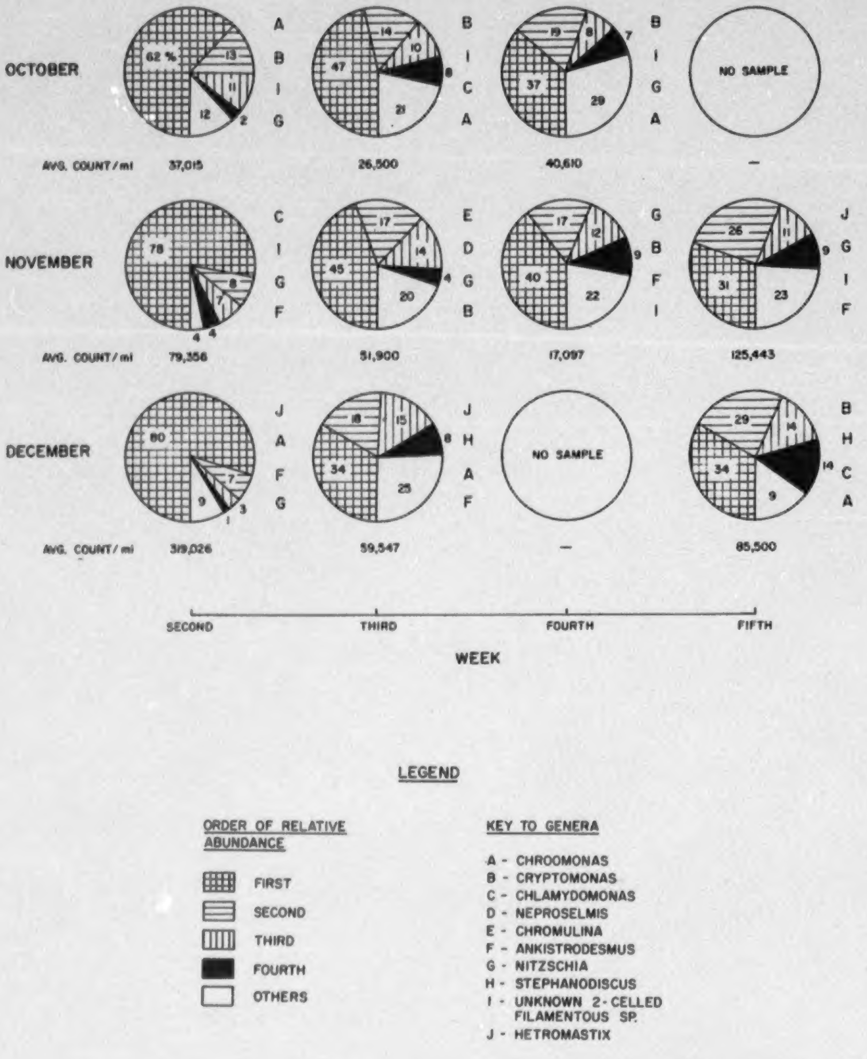
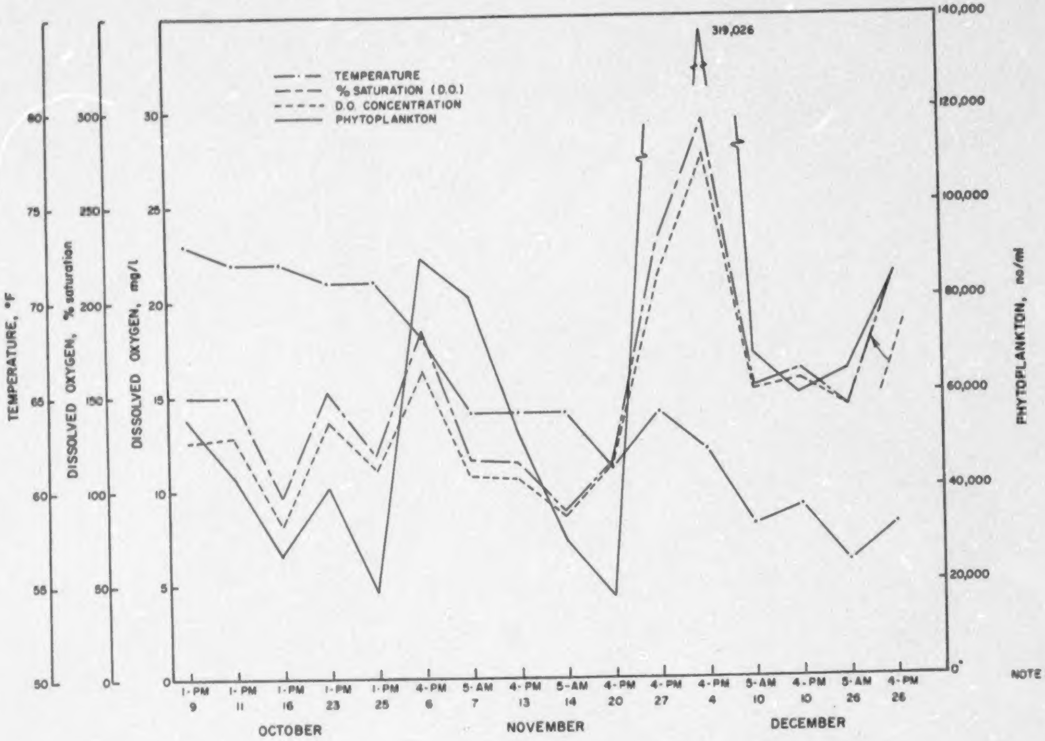


FIGURE 26

DOMINANT GENERA OF PHYTOPLANKTON IN LAKE 4



NOTE: EACH POINT REPRESENTS AN AVERAGE OF THE THREE STATIONS

FIGURE 27

TEMPERATURE, DISSOLVED OXYGEN, PER CENT SATURATION, AND PHYTOPLANKTON COUNTS AT SURFACE SAMPLING STATIONS B-1, B-2, AND B-3 IN LAKE 4

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SANTEE, CALIFORNIA

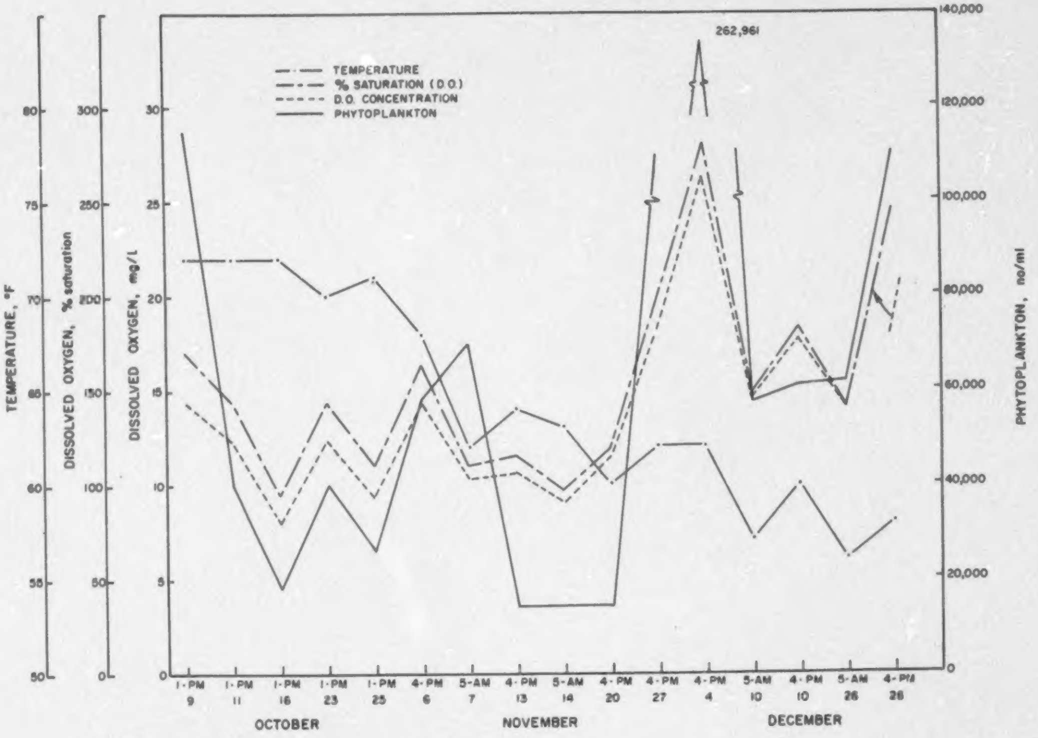

FIGURE 28

TEMPERATURE - DISSOLVED OXYGEN - PHYTOPLANKTON AT STATION B-1b (BOTTOM AT 2 FT.) IN LAKE 4

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SANTEE, CALIFORNIA

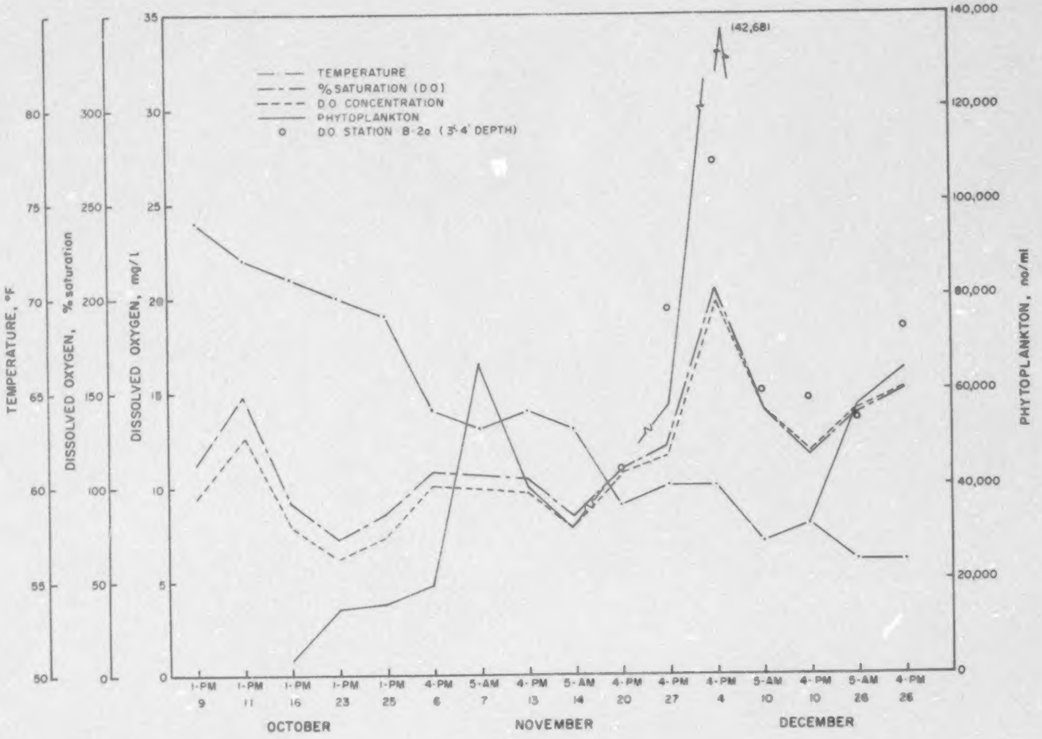

FIGURE 29

TEMPERATURE - DISSOLVED OXYGEN - PHYTOPLANKTON AT STATION B-2b (BOTTOM AT 6 FT.) IN LAKE 4

SANTEE RECREATION PROJECT
SANTEE, CALIFORNIA

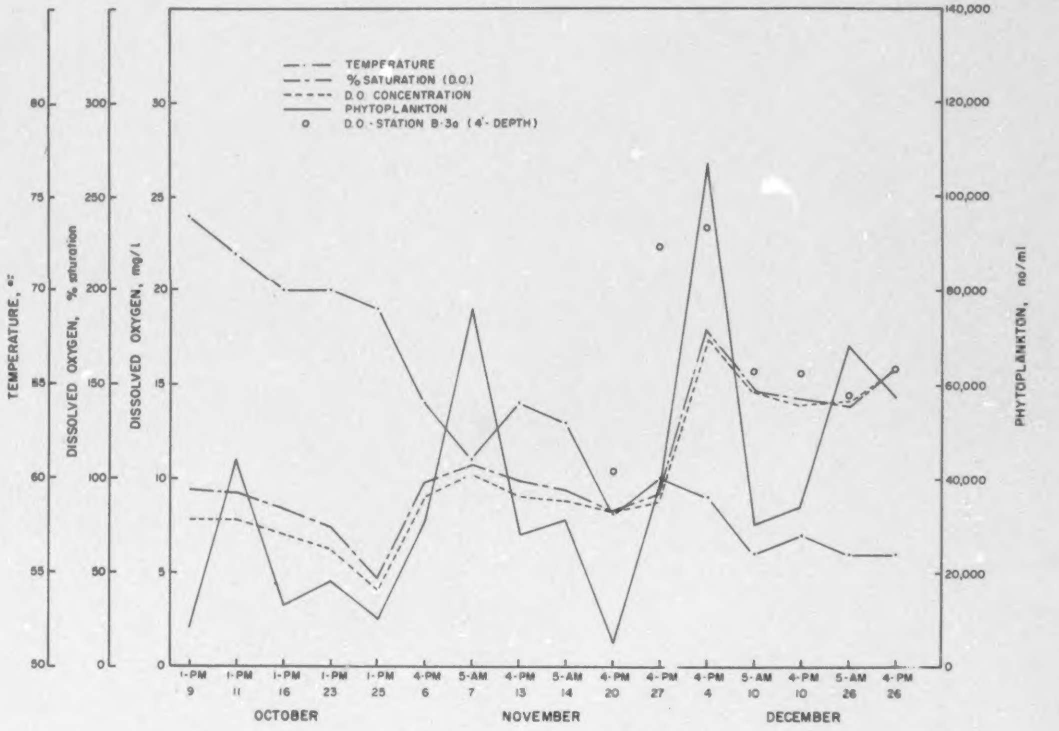

FIGURE 30

TEMPERATURE - DISSOLVED OXYGEN - PHYTOPLANKTON
AT STATION B-3b (BOTTOM AT 8 FT.) IN LAKE 4

SANTEE RECREATION PROJECT
SANTEE, CALIFORNIA

Zooplankton

Zooplankton were never abundant in Lake 4. In Lake 1 there was only the single report by the City of San Diego Water Laboratory of "great quantities" of a cladoceran (*Bosmina* *sps*.) for May 17th. On December 11, 1962, dense, reddish-brown masses of bryozoan statoblasts* (floatoblasts) were observed in Lake 3 coincidental with a fish kill. Table 15 summarizes the zooplankton data for 1962. It is apparent from this table that the data is insufficient for forming conclusions. As the lakes reach a greater degree of stability and age, zooplankton may assume greater proportions and significance.

Benthic Organisms

Lakes 2, 3, and 4 bottoms are alike in that they are composed of lightly-packed conglomerate typical of dry stream beds. Particle size ranges from sand to boulders up to several feet in diameter. No really functional sampling gear for this type of substrate has been developed yet. In the meantime, bottom sampling in these lakes has been limited to seeking out "soft" spots which could be grabbed by a modified Ekman dredge, or a hand-held scoop designed by the Bureau of Vector Control of the California State Department of Public Health. The Oxidation Pond presents a quite opposite condition since the bottom is covered with a soft "floc" or mud-sludge combination.

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* While adult bryozoans may more properly be considered as benthic fauna, their statoblasts were found in plankton samples and they are, therefore, included here.

The sampling in this lake is being solved by simple modifications of the dredge.

Beginning in February 1962, the Sewage Treatment Section, Testing and Control Division of the Utilities Department of the City of San Diego initiated the investigation of bottom fauna in the lakes. Their sampling was confined to the Oxidation Pond and Lake 4. Sampling stations were selected to give a cross section of the bottom, and on this basis, three stations across each end of the Oxidation Pond and ten stations, of which three each were across each end and four were around the middle of Lake 4. A single sample was collected, screened and analyzed from each station.

Five of the six samples from the Oxidation Pond contained aquatic invertebrates. Larvae and pupae of a gnat, *Tendipes sp.* were predominant, ranging from 16 per sq. ft. at one of the upper (southwest corner) stations to 68 organisms per square foot from the middle station at the lower (north) end of the lake. The average number of gnat organisms per station was 141 per sq. ft. No other aquatic invertebrates were collected at this time from the sludge of the Oxidation Pond. In general, the Tendipedid fauna was most numerous at the north (outlet) end of the lake (away from the treatment plant discharge) where the lake is quite shallow, and, during February, contained a growth of unidentified aquatic plants. At the south end of the lake, the water is considerably deeper and possibly anaerobic at the bottom, since the bottom samples had a strong H_2S odor. These factors may have been limiting as far as the immature forms of the gnat were concerned.

Table 15

Record of zooplankton collected in 1962 from the Santee Recreation Project lakes, Santee, California

Group	Oxidation Pond Before Chlorination						Oxidation Pond After Chlorination				Lake 3	Lake 4		
	May		August				May	July	August		Dec.	May	August	
	8	17	7	9	14	16	8	17	14	16	11	8	9	16
Protozoans*			7,040	1,760	880								880	
Bryozoans											Dense mass of Statoblasts			
Rotifers												120		880
Cladocerans	200	100-150				1	200	50-70	10	**				

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* All counts are number of organisms per milliliter

** "Numerous dead specimens", only

Eight of the ten samples from Lake 4 contained identifiable organisms. In these samples, the Tendipedid organisms ranged from 4 to 144 per sq. ft. with an average of 32 per sample, and a species of snail, Physa gyrina, ranged from 4 to 48 per sq. ft. with an average of 16 per sample. In addition, at one station at the outlet end of Lake 4, a single cast skin of a dragonfly naiad, Pachydiplax longipennis was found. An odor of H_2S was noticed also in Lake 4 during the February sampling, but only at one station near the center.

No other benthic organisms were recovered in either lake during this first sampling period.

Around the first of July, 1962, the California State Department of Public Health, through its Bureau of Vector Control, and in cooperation with the University of California at Riverside and the San Diego County Health Department, began a more intensive program of benthic sampling, with emphasis on the Tendipedid midges or gnats. This program is continuing into 1963. The work accomplished during the second half of 1962 is presented in detail in a separate appendix, which will be available for inspection at the Public Health Service office in San Francisco; only a summary of the results is given here.

Collecting was done throughout the project area waterways on a bi-weekly basis from July 9 to December 10, 1962, using a variety of techniques. In the Oxidation Pond and Lakes 2, 3 and 4, bottom organisms were collected at three or four stations located around the shoreline of each lake, using a six-inch, screened mud scoop on the end of a pole. Vector Control personnel defined "benthonic" organisms as "macroscopic invertebrates living in bottom substrates... that can be collected and retained by a screen having openings of 0.5 mm square", and this was the size seive used to strain out the organisms for identification and counting.

Among the several animal forms collected from the bottom, only the dipteran larvae were recorded quantitatively. Their average numbers per square foot over the entire sampling period in the Oxidation Pond and Lakes 2, 3 and 4 were respectively, 2020, 1840, 656 and 530. The greater productivity in the Oxidation Pond and Lake 2 may reflect the absence of fish life, since neither lake was planted, and the recruitment of fish in Lake 2 from Lake 3 probably took place slowly and late in the season. In plotting average numbers of larvae per square foot of bottom substrate against the mean weekly temperatures, there was little correlation, although in general more midge larvae appeared to be produced in the fall than during the summer or winter months. Two tubificid genera, Limnodrilus sps. and Tubifex sps., were reported. No mosquito larvae were noted along the edges of the four lakes, nor were there any complaints about either the mosquitoes or the midges.

During the latter part of this same period, Public Health Service personnel also made benthic collections. These samples were all collected in Lake 4 in somewhat deeper water (up to about eight feet). Results were quite similar to the Bureau of Vector Control data, although there were only about half as many Tendipedid larvae per square foot. In addition, sampling on November 20, 1962, in Lake 4 turned up naiads of a large dragonfly, Libellula sp. and several damselflies. Discovery of these forms has been encouraging, for they are relatively intolerant of pollution, and their scarcity in earlier collecting was rather puzzling.

It is concluded from the above results that Lake 4 is producing an adequate amount of aquatic invertebrate forage for fishes even if these are predominantly dipteran forms. The Oxidation Pond is producing large numbers of these forms, showing that while dissolved oxygen concentrations are frequently below the critical level for fish life, there is still enough oxygen to support other aerobic forms.

The Fishery

Among the recreational pursuits allowed at the Santee Recreation Project, "Fishing for Fun" has perhaps been the most popular, especially for children. The "Fishing for Fun" program requires, among other things, that (1) all game fishes (except the sunfishes) must be returned to the water, and (2) all sunfishes must be turned over to an attendant who will dispose of them. The first requirement is based on the principle objective of the Santee Recreation Project to determine whether or not the recreational lakes can be maintained and used without exposing the public to possible infection from harmful bacteria and viruses. Thus, no fish may be eaten until studies prove that this is safe. The second requirement seeks to prevent a build-up of the sunfish population to the detriment of the game fishes, as happens so frequently in farm ponds containing similar combinations of warm-water fishes.

Since early in 1961, the California State Department of Fish and Game has been planting the lakes with a variety of warm-water fishes. Table 16 shows the planting through 1962. In June 1961, adult red ear sunfish, *Lepomis microlophus*; and threadfin shad, *Dorosoma* petenense, and yearling largemouth bass, Micropterus salmoides, were planted in Lake 4. Six months later adult channel catfish, Ictalurus punctatus, were also planted there. In addition, 19 rainbow trout, Salmo gairdnerii, were put in the lake during the 1961-62 winter season. Lake 3 received plants of Florida largemouth bass, threadfin shad and channel catfish, between June 1961 and October 1962.

Follow-up test seining has showed that in addition to the fish species officially planted, Lake 4 also supports several other species. Bluegill sunfishes, Lepomis macrochirus, are not present, presumably from an unauthorized plant. Mosquitofish, Gambusia affinis, are also present as a result of an unrecorded plant by a mosquito abatement group. Lake 3 contains the same fishes as Lake 4, with the exception of the rainbow trout, although seining did not reveal any catfish, despite the October 1962 plant.

No fish were planted in either the Oxidation Pond or Lake 2, but the latter now contains bluegill sunfish, threadfin shad, mosquitofish and green sunfish, Lepomis cyanellus. These fish probably managed to come down the line from Lake 3, since Lake 2 is "downstream". The source of the green sunfish is unknown, but may have been among the bluegill sunfish which were put in Lake 4, although this species has not been found in either Lake 4 or Lake 3. Official planting is planned for Lake 2 in 1963.

Test seining has also provided some information on growth and reproduction. The red-ear sunfish and the threadfin shad have spawned in both Lakes 3 and 4, but there has been no spawning of bass, since they will not become sexually mature until the early summer of 1963.

Table 16

Record of Fish Planting, 1961-1962, Santee Recreation Project Lakes

Santee, California

Lake 3 (2d recreational pond)

Date	BG*	LMB	RS	TS	RT	CC	FS
June 21, 1961							
March 27, 1962	118			2000			
Oct. 15, 1962						500	
Total	118			2000		500	

Lake 4 (1st recreational pond)

Date	BG	LMB	RS	TS	RT	CC	FS
May 15, 1961	12						
June 20, 1961		90	50				
June 21, 1961				2000			
Nov. 20, 1961					11		
Dec. 8, 1961					8		
Dec. 15, 1961		62				25	
July 6, 1962							100
Oct. 15, 1962						500	
Total	12	152	50	2000	19	525	100

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*Species abbreviations are:

BG = Bluegill
LMB = Largemouth bass
RS = Red-ear sunfish
TS = Threadfin shad
RT = Rainbow trout
CC = Channel catfish
FS = Freshwater shrimp

Because the channel catfish also showed no signs of spawning, in spite of adults having been planted originally, additional numbers (fingerlings) were planted in the fall of 1962.

The results of the test seining as far as growth of fishes is concerned have not yet been completely analyzed. To date it is evident that panfish growth in Lake 4 is slower than in Lake 3. This may be due to a difference in density of fish populations in the two lakes, although Lake 3 appears to have an extremely large fish population, and in Lake 4 the "Fishing for Fun" acts, selectively, to prevent a stunted population.

The purpose of putting threadfin shad in these lakes has been to provide an intermediate link in the food chain between the plankton and aquatic invertebrates, and the game fishes. The shad is an open-water species which feeds primarily on plankton and is considered an excellent forage fish. It is hoped that ultimately two lines of study may be pursued: (1) a stomach analysis of the game and forage fishes, and (2) an analysis of the whole shad in order to determine the role of fish life in utilizing the great quantity of nutrient material that is available. Shad may prove helpful in preventing algae and gnat nuisances and the fishing program may result in the removal of some of the surplus nutrients by harvesting the fish crop. In addition to the shad as a forage species, a fresh-water shrimp species, Palaemonetes paludosus, has also been planted in Lake 4, but there is no definite knowledge yet as to the success of the plant.

More detailed observations on the shad population in Lake 3 were provided by a fish kill which occurred in December 1962. At this time, by conservative estimate, at least 10,000 shad died. Undoubtedly the figure should be considerably higher, for gulls and other scavengers consumed enormous numbers not included in the estimate. Subsequent seining revealed only a few dozen shad remaining in the pond. Most causes for the kill were ruled out, since water in Lake 3 is derived from Lake 4 and flows into Lake 2, yet no fish died in either of the adjacent lakes. In addition, no other fish or other aquatic life, including the gulls which ate the dead and dying shad, were affected. It is believed that whatever factors were involved must have been barely at the tolerance threshhold level for shad, a very sensitive fish, and thus nearly impossible to detect. Three of these factors are (1) the possible toxic effect of a "bloom" of bryozoan statoblasts, (2) residual malathion insecticide in bottom muds, recirculated by a possible small-scale turnover and (3) a possible rise of ammonia in the un-ionized form along with higher pH values. All of these possibilities are still under investigation.

It should be emphasized here that the possible causes for the fish kill do not imply a poor degree of waste treatment nor a hazard to human health. The loss of shad is not serious, since the kill has illustrated the ability of the shad to reproduce abundantly and to grow adequately in this environment. More shad will be replanted to reestablish a large population quickly. Because the shad are a forage fish, their sudden decrease in numbers will not reduce the quality of the fishing, but might actually enhance it by forcing the game fishes to turn more readily to the anglers baits and lures.

Although the water for the recreation lakes is derived from domestic sewage, the degree of treatment obtained before reaching the lakes already appears adequate to provide water of suitable quality for fish life. The highly nutrient-laden reclaimed water does promote the growth of algae, particularly the filamentous and attached kinds, but this seems to be more of a nuisance to fishing than a hazard to the fish. Furthermore, control by means of copper sulfate, at levels not toxic to fish life, have thus far been reasonably successful. The nutrients also provide materials for suitable growth of fish. Dissolved oxygen concentrations and temperatures, as noted earlier in the report, are sufficient. The bottom composition in all three of the recreational lakes has been adequate for the reproduction of centrarchid fishes, although further study may reveal the need for some form of shelter for catfish spawning.

The many, varied aspects of the fishery of the Santee Recreation Project lakes will be covered in a detailed report which is currently being prepared by the California State Department of Fish and Game.

Other Aquatic or Semi-aquatic Vertebrates

Other aquatic vertebrates besides fishes, found at the project, are frogs - a few bullfrog tadpoles, *Rana catesbeiana*, have been observed - and birds. The following birds have been recorded:

Podilymbus podiceps	- pied-billed grebe
Ardea herodias	- great blue heron
Casmerodius albus	- common egret
Nycticorax nycticorax	- black-crowned night heron
Branta canadensis	- Canada goose
Aix sponsa	- wood duck

Fulica americana	- American coot
Larus argentatus	- herring gull
Thalasseus maximus	- royal tern
Hydroprogne caspia	- Caspian tern
Megaceryle alcyon	- belted kingfisher

There are also a number of other species, including gulls, terns, waterfowl and sandpipers, on which specific identification has not yet been made.

There are several reasons why bird life at the recreation lakes is worthy of some attention. First, and foremost is the influence which some of the waterfowl have upon the coliform counts. The coots have established almost a permanent residence at the lakes and they number at least 400. Since coliform bacteria counts are used as an indication of pollution or conversely of the degree of waste treatment achieved, a source from other than the treated effluent can result in some very misleading figures. In addition, the coots have been very instrumental in destroying the grass cover along the shoreline and in creating a nuisance because of their droppings which are everywhere. In the fall of 1962, the Santee County Water District obtained permission from the Fish and Wildlife Service to attempt control by shooting, but thus far these efforts have not proved especially successful. The supply of coots appears to be infinite.

Another aspect regarding aquatic bird life at the lakes is the effect which certain forms may have upon the fish life. Many of the species thus far recorded will readily eat fish, either dead or alive, and when fish populations are concentrated, there could be a significant loss of fish.

Birds may also be indicators of pollution. In the case of the gulls which, as scavengers, cleaned up many of the dead shad during the fish kill, if the kill had been the result of some toxic substance, it might have been possible to identify the substance by analyzing the bodies of gulls which would also be affected. The death of grebes in Clear Lake, California, due to DDT is also an example. Waterfowl frequently suffer from the effects of botulism and this is another way in which they would serve as indicator organisms.

And finally, there is the aesthetic aspect of the lakes. For many people, the observation of bird life provides an excellent form of recreation. Although it is quite obvious that newly-created bodies of water will attract aquatic birds, the numbers and kinds of birds are both an advertisement as to the quality of the water and additional publicity as to the attractiveness of the area. These bird populations are natural, and to many people's way of thinking, preferable to the semi-domesticated rafts found in some public parks.

Summary and Future Plans

During the first year of the cooperative water reclamation study at Santee, a background of physical, chemical, and bacteriological water quality information has been developed along with flow characteristics for all of the stages of the project. Since the primary emphasis of this project is the evaluation of man's recreational use of an environment supplied with waste water, the development of separate studies in microbiology for detection and identification of virus, and in aquatic biology have been started.

Results of the investigations thus far show that the conventional treatment processes generally performed satisfactorily for the flow of 0.9 mgd while the general water aquifer is limited in transmission capacity to far less than the 0.72 mgd. Table 17 shows, however, that for all constituents of the waste water except COD and ABS, the final water entering the recreational lake was effectively treated. A good share of this control resulted from the percolation process, even though underground travel was limited.

A study of the plankton populations also revealed a satisfactory degree of treatment. Lake 4 contained a diverse population typical of very rich, natural waters, although plankton blooms were quite high at times. This did not create a serious nuisance. The Oxidation Pond was borderline as far as normal oxidation ponds and plankton are concerned. Considering the long detention time, it could stand a much higher loading, if necessary. At the current loading, optimal plankton populations are not being maintained, but this may be an advantage in preventing a nuisance from developing. Zooplankton studies were not sufficiently detailed to draw any conclusions, but it appears that a larger, highly fluctuating population should ultimately develop in Lake 4.

Benthic fauna studies to date have been limited because of an adverse lake bottom. Thus far records show a high population of midges which have not yet created a nuisance.

A successful fishery has been developed, and although a fish kill occurred, it has not been significant either as far as human health or the continuance of the fishery is concerned.

TABLE 17

SANTEE WATER QUALITY SUMMARY

1962 AVERAGE (Medium for Bacteria)

LOCATION

	Plant Inlet	2nd Effluent	Oxidation Pond		Rec. Lake 4	
			Bcl	Acl.	Inlet	Outlet
Flow MGD	0.90	0.90	.72	.72	.60	.40
Susp. Solids Mg/L	516	47	70	77	7	12
Vol. Sus. Solids	450	43	66	72	4	7
BOD	299	33	—	—	34	—
COD	1180	178	226	213	50	55
T.D.S.	1140	1060	1110	1110	940	1000
Chloride Cl	205	206	215	224	217	224
Nitrate N	.15	.16	.19	.31	.35	.14
Ammonia N	33.1	26.6	15.9	14.9	.74	.08
Organic N	30.5	7.9	12.1	10.9	1.24	1.63
Phosphate PO_4	63	23	26	23	1.6	1.1
ABS	17.8	8.9	7.5	7.0	3.4	32
Coliform MDN/100 ml	49×10^6	18×10^6	5.1×10^5	4.5	4800	1440
Fecal Coli	13×10^6	8×10^6	$< 1.4 \times 10^5$	< 2	160	18
Fecal Strep.	1.3×10^6	$.79 \times 10^6$	4600	< 2	330	33

Other aquatic or semi-aquatic vertebrates, primarily birds, have added to the aesthetic value of the recreational lakes. Of these, the coots have reached such numbers that they are now a definite nuisance and may interfere with use of the lakes by the public.

Changes in the operation during the second year of the investigation include the diversion of a portion of the chlorinated oxidation pond effluent to Lake 2 so that more effective ABS removal could be accomplished in the percolation area. In addition the installation of a chlorinator at the inlet of Lake 4 will provide more exact control of bacterial quality in the Lake and will allow a non-chlorinated water to be applied to the fenced percolation area.

Plans for the second year also include the start of an epidemiological study that will provide a community health correlation for the virus identification now in progress.

Work on aquatic biology will be greatly facilitated by improved working conditions which will be available early in 1963. During the 1963 calendar year, efforts will be directed toward increased emphasis on the identification to species of significant organisms, the measurement of appropriate additional parameters coincidental with the plankton samples and the development of more adequate bottom sampling, and hence, more comprehensive characterization of the benthic fauna. Fisheries management will continue with additional experimental planting of fish, and if possible, fish population, food habit and productivity studies.

Acknowledgements

This report has utilized many contributions from the several cooperating agencies. Special recognition for each contribution will be included in the final report on the project.

APPENDIX A

DHEW Region IX, Public Health Service
Water Supply and Pollution Control
447 Federal Office Building
San Francisco 2, California

SANTEE WATER RECLAMATION PROJECT

MEMORANDUM OF UNDERSTANDING

April 13, 1962

I. The following agencies: United States Public Health Service, California State Water Pollution Control Board, California State Department of Public Health, California Department of Water Resources, California Department of Fish and Game, San Diego County Department of Public Health, and Santee County Water District, agree that the currently operated sewage treatment and water reclamation facilities of the Santee County Water District present an ideal opportunity for studying the reuse of waste water for recreational and recharge purposes. These agencies therefore have agreed to join in a cooperative study to be known as the "Santee Water Reclamation Project." Each agency shall have at least one representative on a Project Advisory Committee which will guide the project.

II. Contributions of resources by each of the above agencies to this project in fiscal years 1961-62 and 1962-63 shall include but not be limited to the following:

A. The United States Public Health Service agrees to provide:

1. The project coordinator, available as necessary,

2. The project report, including a monthly summary of accomplishments,

3. Support for certain aspects of the project, including weekly chemical and biological analyses and consultation on aquatic biological aspects,

4. Support, if necessary, for enterovirus determinations in the San Diego County Health Department laboratory,

5. Assistance and technical support as necessary from the staff of the Sanitary Engineering Center at Cincinnati, Ohio, and

6. Support to the Santee County Water District to make beneficial changes in the percolation area to provide for optimum treatment of the waste waters.

B. The California State Department of Public Health agrees to provide:

1. A mobile laboratory with two chemists and a laboratory assistant to perform the four-hour cycle of bacterial and related chemical determinations for two-week periods, four times per year, on or about the first of February, May, August, and November,

2. An epidemiology traineeship (an M.D.) assigned full-time to the project to make an epidemiological study of recreational users at the Santee Lakes,

3. Radioactivity determinations as frequently as the project coordinator decides to be necessary, and

4. One-fourth to one-half time of a vector control technician.

C. The California State Department of Water Resources agrees to provide:

1. Assistance for sampling transportation and chemical

analyses during each of the two-week periods the State Health Department mobile laboratory is on the site,

2. A ground water- hydrology study of the Sycamore basin,

3. A flow rating device and two water stage recorders as required on the project, and

4. A recording conductivity meter for monitoring of water quality during the intensive two-week sampling periods.

D. The California Department of Fish and Game agrees to provide:

1. General assistance in the fish management program,

2. Fish for stocking purposes and study as needed and as the supply will permit,

3. Fish handling equipment including nets, etc., and

4. Assistance in sampling fish and other aquatic organisms as time, personnel and equipment will permit.

E. The San Diego County Department of Public Health Agrees to provide:

1. Office space and stenographic services for the project coordinator and epidemiologist trainee,

2. Laboratory analyses for coliform, fecal coliform and fecal streptococci for the eight weekly samples obtained from various locations in the project during the intervening periods between mobile laboratory assignments,

3. Laboratory studies of enteroviruses in the sewage and waste water in accord with recommendations of the technical advisors to the project within the capability of the support

of the California Water Pollution Control Board and United States Public Health Service,

4. Field and laboratory examinations for gnat and mosquito larvae at possible two-week or weekly intervals during their growing season, and

5. Transportation of all samples from Santee to the laboratory.

F. The Santee County Water District agrees to provide:

1. Access to and the use of the sewage treatment and water reclamation facility including the spreading grounds and recreational lakes for the research study,

2. Working space, water, electric and waste water services as necessary for the mobile laboratory or other on-site tests performed in this study,

3. All bacterial and chemical sample collection and gage height and flow measurements at four-hour intervals during each two-week intensive sampling period and weekly during the intervening periods,

4. Operating changes in the treatment procedures or facility according to the Research Plan or when significant results of laboratory analyses make a change desirable to provide new data,

5. Records of plant operation including flow records and operating changes and results of any field tests performed by plant personnel,

6. Assistance in establishing additional wells to monitor ground water movement and quality, and

7. Assistance to the technical staff in the various activities associated with the project.

III. The proposed research program has the overall goal of utilizing the sewage reclamation plant and recreation facility operated by the Santee County Water District to provide information regarding the degree of treatment necessary to make a reclaimed water suitable for recreational use, replenishment of ground water, and other possible beneficial uses. The agencies participating in the project agree, however, that any beneficial changes in the research program that can be provided by increasing the number of participants or the range of research will be acceptable.